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MANAGEMENT HANDBOOK

To Aid Emergency Expansion of

Dehydration Facilities for Vegetables and Fruits

VOLUME II
POTATO SUPPLEMENT

Part One - - Potato Dice
Part Two - - Potato Granules

A Phase II Preparedness Study

Prepared at the Request of
Office of the Quartermaster General
Department of the Army
Washington, D. C.

By

Western Regional Research Laboratory
Bureau of Agricultural and Industrial Chemistry
Agricultural Research Administration
U. S. Department of Agriculture

MAY 1952

(Courtesy of Santa Fe Railway)

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Part One

POTATO HALF-DICE DEHYDRATION PLANT

(Type I)

CHAPTER I

BASIC ASSUMPTIONS

Foreword

The planning of a dehydration plant meeting national emergency needs should take full cognizance of the information and suggestions given in Volume I of this Handbook. This set of plans for a POTATO DEHYDRATION PLANT is based upon the principles set forth in that portion of the Handbook.

Product Desired

The plant covered in Part I of this Supplement of the Handbook is designed to produce dehydrated potato half-dice (Type I) in accordance with the Military Specification "Potatoes, White, Dehydrated" (MIL-P-1073A) dated 12 December 1950. It will be possible for this plant to produce full-dice or Julienne (Type II) dehydrated potatoes by changes in the cutting equipment; plant capacity will be less, however, for those products.

Bases for Operations, Facilities, and Cost Estimates

A. Location of Plant

Most of the potatoes used for dehydration during World War II came from Idaho and Maine, because those areas were the major producers of the varieties best suited for dehydration. These areas are still considered the best sources of suitable potatoes for dehydration. Accordingly, the following estimates are based on a plant located in Idaho. The general plan, design, and operations are applicable, however, to plants located in other areas.

B. Operating Basis

Design and cost estimates are based upon an operation of three 8-hour shifts per day, six days per week, and 200 operating days per year. Labor costs are based on typical labor rates for 1951 in Idaho which are as follows:

Class Labor	Hourly Rate
1	$1.50
2	1.30
3	1.15
4	1.05
5	0.95
6	0.85

C. Raw Commodity Used

In line with successful commercial experience, the variety of potato most likely to be used for dehydration is the Russet Burbank which is grown chiefly in Idaho. Other suitable varieties are discussed in Chapter II -- "Supply of Raw Potatoes".

Provision has been made in the cost estimates for raw commodity prices ranging from \$10 to \$60 per ton delivered to the plant.

D. Plant Capacity and Yields

<u>This plant has been designed to process 100 tons of raw potatoes per day.</u> It is assumed that the preparation line will operate 20 hours per day and have a nominal capacity of 5 tons of raw potatoes per hour. The dehydration tunnels and bins will operate 24 hours per day to dry the material prepared in 20 hours. The packaging line will operate 20 hours per day.

Potato dehydration plants operating during World War II experienced over-all shrinkage ratios ranging from 6 : 1 to 9 : 1. Using potatoes of good dehydration characteristics and of sound condition, a plant should be able to realize an over-all shrinkage ratio of 7 : 1 under careful operation. <u>The cost estimates in these plans, therefore, are based upon a 7 : 1 over-all shrinkage ratio</u> — one hundred pounds of raw potatoes yield 14.3 pounds of diced Type I product.

E. Storage Space

Storage space in the plant building is provided in this set of plans for handling a raw potato supply equivalent to five to seven days of plant operation. In addition, storage space has been provided for a maximum of approximately 30 days' production of dehydrated potato dice plus a 10-day supply of empty cans and cases, or any desired combination of these items.

F. Waste Disposal

It is assumed that the potato solid wastes, amounting to about 20 tons per day, will be hauled away at a cost of \$2 per ton.

CHAPTER II

SUPPLY OF RAW POTATOES

Characteristics Desired in Potatoes to be Dehydrated

The Military Specification (Potatoes, White, Dehydrated, MIL-P-1073A dated 12 December 1950) requires that: "The potatoes used for dehydration shall be sound, mature, of similar drying characteristics, and of mealy texture when cooked. Potatoes which discolor or become soggy after boiling shall not be used. The following varieties are suggested: Russet Burbank, Rural Russet, Green Mountain, Triumph, Katahdin, or varieties of similar characteristics. Potatoes affected by sunburn shall not be used." Other characteristics desired in white potatoes to be used for dehydration are: relatively high solids-content, large size, smooth surface, uniform shape, and low reducing-sugar content.

A high specific gravity is desirable in potatoes to be used for dehydration because it has been found to be directly related to dryness and mealiness. The best potatoes for dehydrating are those that are mealy after being cooked.

Fully matured potatoes are much preferred for dehydrating because,usually, they are larger, they have a higher specific gravity and solids content, and are more mealy and less prone to turn yellow during dehydration. Large size, clean smooth skin, and minimum protuberances result in reduced peeling losses and costs of preparation.

Although each potato variety does have some outstanding characteristics which distinguish it from others (such as shape, size, color, skin texture, eyes, disease-resistance, etc., yet for many of the characteristics of special concern to the dehydrator there is sometimes a greater variation between lots of the same variety grown in different locations than between different varieties grown in the same location. These characteristics are solids content, specific gravity, mealiness, reducing sugar, and starch content. Growing, harvesting, and storage conditions all have their effect on these characteristics, as do climate, soil type, fertilizer use, and degree of maturity before harvest. Specific gravity of potatoes increases with maturity and decreases with increased fertilizer and water applications. Other growing conditions which tend to make potatoes low in solids and therefore less desirable for dehydration are excessive growing temperature, and lack of sunshine. The range of these characteristics is illustrated by a lot of Katahdin potatoes whose specific gravity was found to range from 1.083 to 1.062. At the upper level of this range the potatoes were mealy, light and fluffy, and of good flavor. At the lower level they were heavy and pasty and unsuited for dehydration.

<u>The quality and suitability for dehydration are dependent in large measure upon the locality and conditions under which the potato is grown and harvested.</u>

Suitable Dehydration Varieties and Commercial Production Data

A. Varieties

There are about fifty recognized varieties of white potatoes grown commercially in the United States. There are many others that are grown experimentally or on a non-commercial basis. The twelve leading varieties, which account for over 90% of the total production in this country are shown in Table I. Production is evenly divided between older varieties (believed to have been introduced during the last half of the nineteenth century) and newer varieties (introduced through the efforts of the National Potato Breeding Program inaugurated in 1929 to breed disease-resistant potatoes).

The six most important older varieties may be divided into two groups as follows:

1) Cobbler, Green Mountain, and Triumph

These varieties are declining in production. The Cobbler is the most widely distributed of any potato variety, being grown in 36 states. It is adapted to a wide variety of growing conditions, and is the only one of the older varieties which is resistant to mild mosaic disease. It is a mealy potato, relatively high in specific gravity, and has been successfully dehydrated in Yew York State. The Green Mountain is grown largely in New York and New England, is also mealy, and should meet dehydration requirements. Triumph is a red-skinned potato which is grown in northern Colorado, Nebraska, and in the Red River Valley of the North. However, it has a relatively high moisture content, and is a poor keeper. It was dehydrated during World War II, but with only limited success.

2) Russet Burbank, Red McClure, and White Rose

The three varieties of this group all show a relative increase in production during recent years. They are produced in the irrigated lands of the West. The Russet Burbank is remarkably successful in Idaho, and is also of major importance in each of the other Northwestern States. It is a mealy potato, very well suited to dehydration; most of the present and World War II dehydrated potato production was of this variety.

The Red McClure, a red-skinned variety, is also a mealy potato suited to dehydration, but the production is the most restricted geographically of any of the important varieties — important commercial production of this variety is limited to the San Luis Valley of Colorado.

The White Rose is grown in California chiefly for spring and early summer harvest; as an early potato, it is usually harvested while immature, when it has a relatively high water content, is less mealy, and is generally unsuited to dehydration. As a late-potato, this variety is more acceptable for dehydration use. The White Rose formerly was grown in other sections of the country, but it has been replaced because of its tendency to produce knobby and hollow-heart tubers.

The <u>six most important newer varieties</u> may also be divided into <u>two groups</u> as follows:

1) <u>Katahdin, Sebago, and Kennebec</u>

This group consists of the newer varieties most promising in relation to a dehydration program, and all are of importance chiefly in the Northeastern States.

Katahdin, first grown in 1932, now accounts for nearly one-third of this country's potatoes. Katahdin production has nearly doubled in the last five years, due to increases in both yield and acreage. The Katahdin variety, largely because of its resistance to most of the common potato diseases, is replacing many of the older varieties in the Northeast. As grown in the commercial areas where it is popular, it has a relatively high specific gravity and good mealy texture when cooked. It has been successfully dehydrated in New York and Maine.

Sebago, also a new disease-resistant variety, has had a spurt of popularity which is now on the decline; it is being replaced by the other two varieties of this group.

Kennebec is a very new variety which is gaining popularity in Maine. Very large tubers are characteristic of this variety. It appears to be disease-resistant, and tests show it to have a relatively high specific gravity and to be suitable for dehydration.

2) <u>Chippewa, Pontiac, and Red Pontiac</u>

The three varieties of this group of new introductions are less mealy and less suited to dehydration. Chippewa, which is grown chiefly in the Lake States and in the Northeast, has enjoyed only a moderate increase in production in recent years. It is moderately disease-resistant but is a poor keeper, less mealy, and not particularly suited to dehydration. Pontiac, a red-skinned potato, was introduced for growing on the muck lands of Michigan, but now is of chief importance in Minnesota. The Red Pontiac, a deeper red, is a color mutation of the Pontiac. Both of these varieties produce high yields in North Dakota and Minnesota. However, neither is particularly disease-resistant and neither is particularly suitable for dehydration, being relatively low in specific gravity.

The chief characteristics of the principal commercial varieties of potatoes are summarized in Table I.

B. Important Producing Areas

There are 29 states producing potatoes commercially for late harvest. Eighteen of these are "late surplus" States — States having late harvest seasons and producing in excess of State consumption (see Table II). Maine and Idaho are the leading late-potato producing States.

Tables II, III, and IV present, according to States, pertinent data on potato production in the United States.

Among the principal late-potato producing areas of the country which should be given serious consideration as sources of potatoes for dehydration are the following highly concentrated areas of production which are somewhat remote from large consuming markets:

1) The Snake River Valley of Idaho and Oregon

2) Eastern Aroostock County, Maine

3) The Red River Valley of northeastern North Dakota and northwestern Minnesota

4) The Klamath Basin of southern Oregon and northern California

5) The Greeley, Colorado, area

6) The Rio Grande River or San Luis Valley of southern Colorado

7) Central Washington

Other important late-potato producing areas are in Pennsylvania, New York, Michigan, and Wisconsin. Each has suffered a decline of more than 50% in potato acreage during the past 30 years. Their production is scattered through all farming districts and each has large, important city markets nearby.

There are 21 states that produce white potatoes for early and intermediate season harvest. They are chiefly the South Atlantic and Gulf Coast States. Only California produces large quantities of both the late and early crop. California overshadows all other states in the production of the early crop accounting for one-third of the total and having a yield equal to twice the average. (Table III)

The Kern County area of California is by far the most important source of early potatoes. Over 95% of the early production in this area, is of the White Rose variety. The harvest begins in April and continues into June until the days are so hot that the potatoes begin to spoil before they can be shipped.

The early and intermediate harvest does not go into storage except in unusual circumstances. It is grown to meet the current demand and the crop is usually harvested before it is fully mature. <u>It is not a likely source of potatoes of the quality and quantity needed for dehydration</u>.

Procurement Problems

A. Supply of Potato Seed

The quality of seed is a very important factor in the production of potato crops. Through seed certification agencies that have been established in 27 States and in the Dominion of Canada, United States growers now have a reliable and abundant source of seed. For the most part, this self-supporting, and voluntary program of seed-certification is administered by the Department of Agriculture of each State. Regulations provide for standards regarding seed, seed-bed preparation, cultivation, weed control, removal of diseased plants, irrigation practices, handling of the seed crop at digging time, and seed-storage practices. The purpose is to provide seed that is free from disease, freezing, and other injury, and which is true to type and otherwise sound for the purpose. By the payment of a small acreage fee, a seed grower may

obtain the services of a State Inspector who will make several field inspections and a bin inspection after harvest, and will attach certification tags to bags for the designation of the seed that meets the standards.

In some parts of the West, seed is grown under irrigation, and in other parts, it is grown under dry-land conditions having limited rainfall. Seed potatoes are often produced in high mountain valleys surrounding the areas of commercial production. White Rose seed for use in the Kern County area is grown in northern California, Oregon, and Washington, where it matures at a later date. Russet Burbank seed is supplied to Idaho by Washington growers. In general, the seed stock used in producing early potato crops in the South is grown in the Northern States.

Production areas differ widely in their relative production and use of certified seed. In Maine a third of the potato production passes the tests for certification. In Idaho, on the other hand, only a little over 5% of the production is certified. In the latter State it has been the common practice of the commercial growers to buy certified seed and to grow their own seed on isolated fields for the following year. This practice halves the requirements for certified seed but it has often failed to give satisfactory results, owing to the rapid spread of virus diseases. This practice is decreasing. <u>For surety of quality production, it is recommended that only certified seed be planted each year</u>.

The certified seed potato production of the United States in 1951 was 2,200,000,000 pounds grown on 110,000 acres, or an average of 20,000 pounds per acre. This indicates that approximately all of the commercial production of potatoes could come from the certified seed now being grown. Much certified seed, however, does not find its way to the seed market but is sold as table stock.

Price premiums for certified seed will, in general, tend to regulate supplies; but varietal shifts and changes of practice due to dehydration demand may make seed certification less attractive in some areas and more attractive in others. <u>It is not likely that seed production will ever be a critical problem in connection with potato dehydration</u>.

Table V shows certified potato seed production by varieties for the years 1948 through 1951. Although more than 65 varieties of certified seed potatoes are produced in this country, about 94% of all certified seed production is of the 12 varieties shown.

B. Soil, Fertilizer, and Other Cultural Requirements

Potato growing is most successful in areas where the average summer temperatures are low, generally not over 70° F. The potato grows best in sandy or gravelly soil; good crops are also produced on black or clay loam provided the drainage is good. It is essential that the soil remain porous during the growing season; very heavy soils produce many misshapen tubers. The loose porous volcanic soils of the Snake River Valley are especially suited to potato growing. In the Lake States, potatoes are successfully produced on muck or peat soils which are well drained and fertilized.

Clovers and alfalfa usually play an important part in the crop rotation with potatoes to maintain the organic content of the soil and to supply needed nitrogen. Liming is necessary in some areas to produce a satisfactory cover crop, but too much lime will result in scabby potatoes. Increasing the soil acidity after the cover crop is turned under will check the growth of the organisms which cause scab.

The maintenance of an ample supply of organic matter in the soil is one of the most important soil problems in all potato regions, except those with much and peat soils. A supply of decaying organic matter helps keep the soil loose and mellow,

facilitates plowing and cultivating, enables roots of potato plants to penetrate the soil more readily, retains water, and assures nourishment for the growth of desirable soil micro-organisms. Under these conditions potato tubers develop well and attain good shape. Organic matter may be put into the soil by means of crop rotation or by application of barnyard manure before fall plowing. Fresh manure should not be applied just before the potato crop is planted, as it may produce a favorable environment for common scab development. It is best to get manure plowed under early so that it will decay before the crop is planted.

The use of commercial fertilizers is also necessary to secure the best yields. First-hand knowledge of the soil and its previous treatment will permit correction of nutritional deficiencies by this method. The grower or the processor's field agent should consult with the County Agricultural Advisor on this matter.

An abundant water supply is essential in growing potatoes. The soil should be moist at the time of planting and throughout the growing period. In the Western States four times as many acres of potatoes are grown under irrigation as under dry-farming, and the yield for the irrigated crops is about three times that of the dry-farmed. Dry-farm potato growing is largely confined to seed production.

Potatoes normally grown for early or intermediate harvesting should be left in the ground beyond the usual commercial harvest period in order that they may become fully matured before being dug for dehydration. Potatoes grown for early harvest are usually less desirable for dehydration than those grown for late harvest.

C. Harvesting and Transporting of Potatoes

The late crop is harvested when the vines mature or soon after a killing frost. In the late crop areas, harvest begins about the middle of September and lasts about a month or six weeks. Mechanized potato diggers have been greatly improved in recent years and nearly all commercial crops are harvested by machine. Most of the late crop, outside of California, goes immediately into storage to protect the potatoes from the weather and to keep them in condition for later marketing. California potatoes, both early and late, are usually shipped and marketed immediately after they are dug.

Table VI and Figure 1 give planting, harvesting, and shipping periods for the principal potato producing States.

D. Storing and Conditioning Potatoes

Potatoes may be stored for two or three months after harvesting with little noticeable deterioration if protected from freezing. Careful conditioning and good storage facilities are needed to reduce loss and to provide suitable raw material for dehydration for periods extending longer than three months. The storage period may consist of three parts: (1) the initial conditioning period, (2) the dormant period, and (3) the warming or restoration period.

In order to promote the healing of cuts and injuries that have occurred in harvesting and to reduce shrinkage, the potatoes should be held for the first two or three weeks of storage at temperatures of 55° F. to 60° F. and with a high atmospheric humidity. These conditions will normally be easy to provide, for daytime weather conditions at the time of harvest in most storage States would approximate the requirements.

After the initial conditioning or curing period, potatoes should be stored at a lower temperature (38° F. to 40° F.); they may be held dormant for a period up to four or five months at this temperature. This temperature is approximated in well built

pits, cellars, or storage houses in the northern growing districts. If the potatoes are to be kept for a long period (six to eight months) or for seed stock in which any sprouting is undesirable, the temperature should be somewhat lower. However, a temperature as low as 32° F. is not necessary, and may be detrimental. Potatoes freeze at temperatures below 29° F. Storage conditions should include ample circulation of air, atmospheric humidity of 85% to 90%, and the exclusion of all light.

Potatoes stored under the foregoing conditions should not shrink more than 5% throughout the entire winter. Under poor storage conditions, however, the loss in weight may amount to 20%.

The warming, or restoration, period is of special interest to potato dehydrators. Low temperature storage brings about changes in the potato that make it less desirable for dehydration, and these changes must be corrected. Storage below 40° F. causes a large increase in the content of reducing sugar. High-sugar content increases susceptibility to scorching or browning during the dehydration process and shortens the storage life of the dehydrated product. It is generally recognized that a reducing-sugar content above 3% is undesirable for potatoes that are to be dehydrated. The high sugar content can be reduced, however, by a "warming" (or "restoration") period consisting of holding the potatoes at 60° F. to 70° F. for one to three weeks just prior to use. Somewhat higher temperatures will probably shorten the "restoration" time.

E. Competing Outlets for Potatoes

The white potato requirement for dehydration is small in comparison with the total production, and there is little competition for available supply when potato crops are normal or in surplus in the states remote from large consuming markets.

F. Competition With Other Crops for Acreage

The acreage of potatoes grown in the United States varies a great deal with expected demand and price. Potatoes compete with many northern field crops for the use of land. Clover, alfalfa, grain, and corn are crops that often appear in rotation with potatoes.

G. Considerations in Obtaining Potatoes

Certain factors tend to make the procurement of potatoes for a dehydration plant somewhat less difficult than for many of the vegetables used for dehydration:

1) Potatoes are widely produced throughout the United States

2) Potatoes are usually graded according to U.S. Standards

3) Price fluctuations within a given area are minimized by the availability of potatoes from other areas

4) Large quantities of potatoes are produced each year — far more than of any other vegetable

During periods of short supply, however, dehydrators may have difficulty in obtaining potatoes of suitable quality at satisfactory prices. Consequently, <u>contracting with growers in advance for potatoes is the surest way of providing sufficient raw commodity for the operating season</u>. The advantage to this procedure is that the purchaser may predetermine his raw material cost and have more complete control with regard to

seed used, growing and harvesting practices, and conditions of storage after harvesting.

Open market purchases have been widely used by dehydrators in the past and offer some advantages to both buyer and seller. The buyer can inspect the various lots, take samples, test for solids, and arrange to have specified amounts shipped at regular intervals. At harvest time or shortly thereafter, there is a large reservoir of raw material to select from, and the skilled buyer can usually purchase to advantage the raw material that is best suited for his needs. This is particularly advantageous in buying potatoes for the production of granules (which require a mealy potato of high solids content).

Growers of commodities which are commonly stored, such as potatoes, often prefer to await the harvest period before agreeing upon a selling price. If they do not like the price at harvest time, they may prefer to store the crop (assuming storage facilities are available), and sell at a later date when hoped-for higher prices may have materialized.

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TABLE I

Characteristics of the Principal Commercial Varieties of Potatoes

Varieties	Dehydration Rating 1/	Depth of Eyes	Shape of Tuber	Diseases Resisted	Chief Area of Production	Comments	Synonyms
OLDER VARIETIES							
Cobbler 2/	Good	Shallow to deep	Elliptical	Wart, mild mosaic	Eastern, So. Atlantic and Lake States	Often grown as an early potato; being replaced by Katahdin and Chippewa	Irish Cobbler
Green Mountain	Good	Medium	Oblong	Wart	New York and New England	Difficult to grow and store; being replaced by Katahdin and Chippewa	- - - - -
Triumph	Poor	Medium	Round	- - -	Red River Valley of the North, Nebraska, and No. Colorado	Poor keeper, high in moisture, being replaced by Pontiac and Katahdin	Bliss, Bliss Triumph, Red Bliss, Hawaiian Rose, Stray Beauty
Russet Burbank 2/	Very good	Shallow to deep	Long	Scale	Western, irrigated	Large increase in yield and acreage in recent years	Netted Gem, Idaho Russet, Idaho Baker, California Russet, Golden Russet
Red McClure	Good	Shallow	Round	Wart	San Luis Valley of Colorado, irrigated	Premium priced; sport of Perfect Peachblow	- - - - -
White Rose	Fair	Medium	Long	- - -	Western, irrigated	Large increase in yield and acreage in recent years; bulk of harvest in late spring or early summer	Early Long White, Wisconsin Pride, American Giant, Aroostook Wonder
NEWER VARIETIES							
Katahdin 2/	Good (but variable)	Shallow	Elliptical to round	Wart, mild mosaic, net necrosis, leaf roll, brown rot	Northeast	Very large increase in yield and acreage in recent years	- - - - -
Sebago	Good	Shallow	Elliptical	Brown rot, mild mosaic, net necrosis, late blight, common scab, yellow dwarf	Northeast	Being replaced by Katahdin in Maine; cross between Chippewa and Katahdin	- - - - -
Kennebec	Good	- - -	- - -	Late blight, common scab	Northeast	Very new and popular in Maine	- - - - -
Chippewa	Fair	Shallow	Elliptical	Mild mosaic, net necrosis	Northeast and Lake States	Continues to be popular. Poor keeper, early to mature	- - - - -
Pontiac	Fair	Medium	Round to oblong	- - -	Lake States	High yields, cross between Triumph and Katahdin	- - - - -
Red Pontiac	Fair	Medium	Round to oblong	- - -	Red River Valley of the North	High yields, of increasing local importance; color mutation of Pontiac	Dakota Chief

1/ In production areas and under conditions that are prevalent where the variety is commonly grown

2/ Varieties being dehydrated

Sources: Clark, C.F. , and Lombard, P.M. Descriptions of and Key to American Potato Varieties. Washington,D.C.,1946 (U.S. Dept. of Agric. Circular 741)
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TABLE II

Potato Production, Acreage, Yield, and Prices in the Principal Late Surplus States 1/

State	Ten-Year Average - 1940 through 1949 Production 1,000 Tons	Acreage 1,000 Acres	Yield Tons/Acre	Price $/Ton	1949 Price $/Ton	1950 Price $/Ton
Maine	1,790	183	9.8	36	33	27
Idaho	1,121	154	7.3	33	36	22
New York	964	176	5.5	43	37	23
North Dakota	588	148	4.0	34	38	30
Pennsylvania	575	140	4.3	47	44	35
Minnesota	544	170	3.4	37	40	32
Michigan	533	160	3.5	42	42	33
Colorado	520	77	6.8	40	37	40
Wisconsin	381	132	3.1	42	47	42
California 2/	375	38	9.8	47	48	38
Oregon	322	43	7.5	45	42	32
Washington	278	38	7.3	43	46	40
United States (total potato crop)	12,306	2,564	4.9	41	43	33

1/ Other late surplus states are: South Dakota, Nebraska, Montana, Wyoming, Utah, and Nevada. (See text for definition of "late surplus.")

2/ Not including California's early potato crop which averaged 646 thousand tons for 1940-1949.

Computed from data based upon bushels as published in:

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TABLE III

Potato Production, Acreage, Yield, and Prices in the Principal States Harvesting Early or Intermediate Crops

State	Ten-Year Average - 1940 through 1949 Production 1,000 Tons	Acreage 1,000 Acres	Yield Tons/Acre	Price $/Ton	1949 Price $/Ton	1950 Price $/Ton
California	646	58	10.7	43	48	37
New Jersey	336	61	5.6	40	42	27
North Carolina	279	80	3.5	42	45	26
Virginia	270	68	4.0	43	47	31
Texas	139	50	2.8	53	57	51
Florida	129	30	4.4	60	77	56
Alabama	126	46	2.8	43	61	44

Computed from data based upon bushels published in:

U.S. Bur. of Agric. Economics. Crop Production ... Annual Summary, 1951. Washington,D.C.,1951
U.S. Bur. of Agric. Economics. Farm Production, Farm Disposition, and Value of Principal Crops, 1949-50. Washington,D.C.,1951
U.S. Dept. of Agriculture. Agricultural Statistics, 1942-50. Washington,D.C., 1942-50

TABLE IV

Relative Importance of Commercial Potato Varieties by States in 1951

Harvest	First	Second	Third	Fourth
Late				
Maine	Katahdin 52%	Green Mountain 25%	Chippewa 17%	Cobbler 2%
New York	Katahdin 35%	Green Mountain 20%	Sebago 10%	Cobbler 10%
Pennsylvania	Katahdin	Russet Rural	Teton	Sebago
Michigan	Russet Rural 45%	Chippewa 15%	Katahdin 15%	Sebago 10%
Wisconsin	Chippewa 25%	Cobbler 25%	Katahdin 25%	Russet Rural 8%
Minnesota	Cobbler	Triumph	Russet Burbank	Red Warba
North Dakota	Triumph 35%	Pontiac 30%	Cobbler 25%	- - - - -
Colorado	Red McClure	Triumph	Cobbler	Katahdin
Idaho	Russet Burbank 95%	Triumph	White Rose	- - - - -
Oregon	Russet Burbank 74%	White Rose 12%	Burbank 8%	Triumph 5%
Washington	Russet Burbank 65%	White Rose 35%	- - - - -	- - - - -
California	White Rose 65%	Russet Burbank 30%	- - - - -	- - - - -
Early and Intermediate				
New Jersey	Katahdin 65%	Cobbler 20%	Chippewa 10%	Green Mountain 2%
Virginia	Cobbler 60%	Chippewa 10%	Green Mountain 10%	Katahdin 9%
North Carolina	Cobbler	Sequoia	- - - - -	- - - - -
Florida	Sebago	Triumph	Katahdin	- - - - -
Alabama	Triumph 70%	Sebago 30%	- - - - -	- - - - -
Texas	Triumph 60%	White Rose 20%	Cobbler 13%	Pontiac 4%
California	White Rose 95%	Triumph	Pontiac	- - - - -

Based in part on:
American Potato Yearbook, 1951. Westfield, N.J. ,MacFarland Publications, 1951

TABLE V

Production of Certified Seed Potatoes in U.S. by Varieties

	1948	1949	1950	1951
	- - - - - - - -	- thousand	pounds - - -	- - - - - - - - - -
Katahdin	804,200	951,200	987,500	651,000
Cobbler	450,800	326,800	385,100	299,100
Triumph	387,900	337,700	342,700	240,600
Russet Burbank	208,000	189,600	335,700	223,300
White Rose	239,500	223,700	234,000	146,000
Kennebec		1,500	32,300	112,100
Green Mountain	200,000	146,200	132,400	111,300
Red Pontiac	29,900	62,900	120,000	96,000
Chippewa	207,000	311,200	165,500	53,500
Red McClure	61,800	60,900	44,600	45,700
Pontiac	56,300	73,800	76,600	36,400
Sebago	91,000	56,200	48,600	34,600
All others	162,600	153,300	159,000	149,400
TOTAL	2,899,000	2,895,000	3,064,000	2,199,000

Computed from data in:

U.S. Bur. of Agric. Economics, Boise, Idaho. 1951 Production Certified Seed Potatoes. Boise, 1952 (Jan.)

TABLE VI

Usual Planting, Harvesting, and Shipping Periods for Potatoes in Principal Producing States

State	Planting	Harvesting	Shipping	Principal Growing Districts
California	Nov. 1 - Mar. 30 Apr. 1 - May 31	Apr. 10 - July 31 July 15 - Oct. 31	Apr. 10 - July 31 July 15 - Apr. 15	Kern and Riverside Counties Delta and Tule Lake
Washington	Mar. 15- June 10	June 15 - Nov. 10	June 15 - Apr. 1	Central
Oregon	Mar. 1 - June 15	July 1 - Nov. 15	July 1 - May 1	Klamath, Malheur, Crook, and Deschutes Counties
New York	Mar.15 - Apr. 15 May 1 - June 30	July 5 - Oct. 5 Aug. 10 - Oct. 31	July 5 - Mar. 10 Aug. 10 - Apr. 1	Long Island Western New York
Colorado	Apr. 1 - Apr. 25 May 5 - June 15	July 10 - Aug. 15 Sept. 1 - Oct. 12	July 10 - Aug. 15 Sept. 1 - Apr. 10	Weld, Morgan, and Mesa Counties South Platte and San Luis Valleys
Idaho	Mar.25 - Apr. 10 May 10 - June 10	July 14 - Aug. 25 Sept. 1 - Oct. 31	July 14 - Aug. 25 Sept. 1 - May 10	Western Snake River Snake River Valley
Pennsylvania	May 1 - June 15	Aug. 15 - Oct. 31	Aug. 15 - Apr. 1	Southeast section; and Somerset, Potter, and Erie Counties
Minnesota	May 10 - June 15	Aug. 20 - Oct. 15	Aug. 20 - Apr. 15	Red River Valley; central Minn.
North Dakota	May 10 - June 10	Sept. 1 - Oct. 10	Sept. 1 - May 1	Red River Valley
Maine	May 10 - June 8	Sept.10 - Oct. 15	Sept.10 - May 31	Aroostook
Wisconsin	May 22 - June 20	Sept.10 - Oct. 15	Sept.10 - May 1	State wide
Michigan	May 15 - June 15	Sept.25 - Oct. 20	Sept.25 - May 31	State wide

Sources: U.S. Bur. of Agric. Economics. Usual Planting and Harvesting Time for Major Field Crops and Commercial Vegetables for Fresh Market. Washington,D.C.,1948

U.S. Bur. of Agric. Economics. Commercial Truck Crops for Fresh Market. Usual Planting and Harvesting Dates. Washington,D.C.,1951

U.S. Production and Marketing Administration, Bakersfield, California. Marketing Kern District Early Long White Potatoes, 1948-50. Bakersfield,1951

FEEDING POTATOES FROM BULK STORAGE TO PROCESSING LINE
(Courtesy of J. R. Simplot Co.)

CHAPTER III

PLANT PROCEDURES AND FACILITIES

This chapter gives pertinent information concerning the operating procedures and facilities required for a plant to produce DEHYDRATED POTATO HALF-DICE (TYPE I). The information is coded and presented in accordance with the classification key given in Appendix D ("Operation Classification Code") of Volume I. The accompanying flow-sheet, drawings of equipment and facilities, and other illustrative material have been labeled in accordance with this same classification code. (Note: This same classification key has been used in compiling the "Cost of Facilities" and "Total Production Costs", and thus affords a useful cross-reference system for identifying or discussing any phase of the operations and/or costs.)

The operational procedures and facilities needed for this proposed potato dice dehydration plant are presented in accordance with the attached flow-sheet (Figure 2). A floor plan (Figure 3) is given to show the space and arrangement required for the facilities.

100 — RAW MATERIALS

The problems and methods of procuring a suitable supply of potatoes for a dehydration plant have been discussed in "Supply of Raw Potatoes" (Chapter II).

It is assumed that raw material will be hauled in bulk or in sacks, but will be handled at the plant in bulk (see Code 215).

200 — MANUFACTURING OPERATIONS

<u>210</u> — <u>Raw Material Handling</u>

<u>211</u> — <u>Weighing (at plant)</u>

It is assumed that the truck-loads of potatoes will be weighed at the plant. Carlot shipments usually consist of 500 one-hundred pound sacks (50,000 pounds).

<u>212</u> — <u>Unloading and storing (at plant)</u>

A 6- to 7-day supply of raw potatoes will be kept at the plant to assure smooth and continuous operation. It is assumed that the raw commodity will be stored in bulk at the plant.

<u>213</u> — <u>Feeding to line</u>

There are two general methods practiced by the industry for conveying raw potatoes from bulk storage to the preparation line: (1) belt conveying and (2) fluming.

Belt conveying is used most widely. Fluming has the advantage of conveying without cutting or bruising the potatoes, and at the same time fluming softens adhering soil. Because the quantity of water required may be a serious factor in localities where water is at a premium, provision should be made for recirculating the water when this method is used.

Portable belt-conveyors, or belt-conveyors arranged in such a manner as to fan out from a given point, are popular for conveying potatoes within the storage area. These procedures have the advantage of quick accessibility to the various areas of the storage cellar. The main disadvantages, compared with a flume that is recessed in the floor (and thus can be covered), are: (a) the occupation of more floor space, and (b) the increased labor involved in changing the conveyor positions and/or in manually raising the potatoes from the floor level to the conveyor height.

The method proposed in this Supplement employs a combination of the two general methods discussed, eliminating some of the objectionable features of each. A conveyor belt, recessed in the floor, and an elevator-washer are proposed. The recessed belt runs the full free length of the cellar. The floor recess normally is covered with planks to allow use of this floor-space for storage of potatoes yet allowing potatoes to travel underneath on the belt. The planks are removed when it is desired to draw potatoes for feeding to the processing line, and the potatoes are raked or shoveled onto the belt.

An elevator-washer is used to give the potatoes a preliminary washing and to elevate them to the final rotary washers.

<u>214</u> — <u>Sorting</u>

Provision is made for a short sorting belt which removes rocks, rots, or other undesirable matter before the potatoes enter the preparation line (Code 220-230).

<u>215</u> — <u>Handling and loading sacks</u>

It is assumed that upon delivery of potatoes in sacks, the sacks are emptied and the potatoes are stored in bulk.

<u>220-230</u> — <u>Preparing</u>

A diagrammatic sketch of the "preparation line" for the proposed potato plant is given in Figure 4.

<u>221</u> — <u>Washing</u>

A rod-type rotary washer is provided where the potatoes are tumbled while exposed to sprays of water.

<u>222</u> — <u>Preheating</u>

Preheating of potatoes before processing is now common practice for (a) hot washing the commodity, (b) increasing the peeler efficiency by reducing the heating load on the peeler, (c) lowering the peeling losses, and (d) decreasing the lye consumption. In the preheater, the potatoes are heated in water at 140° F. to 160° F. for a period of from four to seven minutes, as required.

A rotary-type preheater is provided in this operation. This machine is similar to the lye peeler illustrated in Figure 9; for the purpose of preheating, no steam-coil section is used, instead, provision is made for heating the water-bath by direct steam injection. Draper-type preheaters also have been used with success in industry, but require more floor space than the rotary type.

223 — Peeling

223.2 — Lye peeling

Both lye and steam peeling methods are used successfully on potatoes. For the proposed plant, lye peeling is provided. A rotary-type lye peeler is included in the plant plans (see Figure 9). This peeler must be designed for a capacity of five tons per hour. Operating conditions for lye peeling of potatoes must be determined by test, but in general, complete submersion of the tubers for a period of two to three minutes in a 14-15% caustic soda solution held at a temperature of from 200° F. to 215° F. will be found satisfactory. Lye consumption generally amounts to about 25 to 30 pounds per ton of potatoes.

A 15,000 gallon lye storage-tank has been provided in these plans — enough for one railroad car-load or approximately a 30-day supply of 50% lye. Also, provision has been made for a lye make-up tank of 500 gallon capacity; it is used either for diluting of the 50% lye to operating strength, or for use when solid or flake lye must be dissolved.

Draper-type lye peelers have also been used successfully for potatoes but require more floor space than the rotary type.

Peeling losses are assumed to be 12% in this operation but may vary from below 8% to over 25% depending on the variety, age, and condition of the tubers at the time of processing, as well as the peeling method employed.

223.9 — Washing (to remove peel)

In this operation, loosened skins and entrained caustic solution are washed off the potatoes. The potatoes tumble through the washer as they are exposed to water sprays. Excessive water spray pressures should be avoided as pitting and gouging will result.

224 — Trimming

The trimming lines normally will require 35 women but the requirements may vary from 30 to 45, depending on the grade of material, peeling efficiency, etc. The trimming lines must be organized and operated so that individual potatoes do not travel the "merry-go-round" circuit unduly long, in order to minimize exposure to air and subsequent darkening of the potatoes. Trimming losses are estimated to be 5% of the original raw material, but may vary from 2% to 20% or higher, depending on the condition of the raw stock, peeling efficiency, discoloration, and other factors.

226 — Dicing

The Military Specification for Type I potatoes requires that the potatoes are cut to 3/8" x 3/8" x 3/16" half-dice. Three dicers are provided in the proposed plant; two dicers are adequate to carry the normal load, but at least one extra dicer and a supply of spare parts are also needed to assure maximum and uninterrupted production.

227 — Blanching and sulfiting

The diced commodity is loaded directly onto the blancher belt at about three to four pounds per square foot (approximately 1" deep) and is exposed to live steam at 200° F. to 210° F. for three to six minutes. A "drag bar" extending the full width of the blancher belt is provided, for spreading the material to a uniform depth.

If it is desired, washing of the unblanched, diced potatoes may be performed by sprays (see Figure No. 3) located at the loading end of the blancher belt.

Sulfiting of potatoes, as with most vegetables, is done in a manner which is best determined by trial. Military specifications require 200 to 500 p.p.m. (as SO_2) in the finished product. In the proposed operation the sulfite in the dehydrated product is assumed to be derived from the sulfur in the fuel oils used in the direct-fired dehydration tunnels. Operators of potato dehydrators have found that when fuel oils containing approximately 0.20% sulfur are burned in direct-fired tunnels, the sulfite content of the dehydrated potato dice is within the requirements of the military specifications. Excessively high-sulfur-bearing oils must be avoided. When low-sulfur-bearing fuels are used, supplemental sulfite must be added by other means. Supplemental sulfiting may be by sprays provided at the discharge end of the blancher.

Wooden tanks are provided for the sulfite solution make-up. Concentration and amount of sulfite solution required to obtain the proper sulfite content in the finished product must be determined by trial. Sulfite solutions generally used are dilute — approximately 0.2% to 1.0%.

240 — Drying

241 — Tunnel drying

241.1 — Tray loading

Tray loading is accomplished by two vibrating chutes which receive material from the blancher belt and which spread the commodity evenly onto the trays. The empty trays are fed onto a drag-chain conveyor located under the blancher, which moves the trays forward and underneath the vibrating chutes. The rate of tray movement is variable so that the tray loading density may be controlled. In this operation, a loading of 1.5 pounds per square foot is assumed, which is in keeping with average commercial practice.

241.2 — Tray stacking

The loaded trays are stacked on the trucks by means of a mechanical stacker. (Trays are stacked both mechanically and manually in industry.)

241.3 — Weighing

Prior to entering the drying tunnel, each loaded truck is weighed on scales built underneath a section of the track.

241.4 — Tunnel operating

Both tunnel driers and conveyor driers have been used successfully for drying potato dice. Tunnel driers are used extensively in the Western States. Both single-stage and two-stage tunnels have been used successfully on potatoes. Because of the greater simplicity in construction and operation, the proposed plant (for use in an emergency) is based upon one-stage driers. One-stage, counter-current tunnel design features are shown in Figures 5 and 6. Eight one-stage tunnels are arranged in pairs with a single combustion chamber and air-blower for each pair. The following data are used as the basis for tunnel requirements:

1)	Direction of air-flow	Counter-current
2)	Air velocity between trays	800 ft./min.
3)	Volume of air per tunnel (Required capacity of a single blower supplying two tunnels is 40,000 c.f.m.)	20,000 c.f.m.
4)	Type of firing	Direct
5)	Method of firing	Overhead
6)	Type of fuel	Mixed #1 and #2 oils
7)	Hot-end air-temperature	160° F.
8)	Tray loading	1.5 lbs./sq. ft.
9)	Size of trays	3 ft. x 6 ft.
10)	Number of trays per truck	25
11)	Maximum number of trucks per single tunnel	12
12)	Moisture content of material entering tunnel	80% to 82%
13)	Moisture content of material leaving tunnel	10% to 11%
14)	Drying time	7 hrs.

241.5 — Tray unloading and stacking

The trays are removed from the trucks by hand and inverted over a hopper. The hopper is equipped with a revolving brush or scraper over which the inverted tray passes. The trays are then turned face up and manually reloaded on a truck.

241.7 — Tray washing

In industry, the frequency of tray washing vàries from three or four times a season, to every time the trays are unloaded. It is assumed in the proposed plant that trays will be washed once a week by a special crew working on Sundays or other periods when the plant is not in operation. Tray washing can be done conveniently on the tray conveyor between the tray loader and stacker (see Figure 4, codes 241.1 and 241.2). Banks of spray nozzles, both above and below the tray level on the conveyor, can be provided for use when the trays are to be washed.

248 — Bin drying

The proposed plant for diced white potatoes employs portable bins and bin-room equipment designed on the basis of the following data:

1) Air flow rate through bins - 100 c.f.m. per sq. ft. of cross-section

2) Inlet air temperature to bins - 140° F.

3) Depth of material in bins - 4 feet

4) Bulk density of semi-dried product - 23 lbs. per cu. ft.

5) Drying time (in bins) - 3 to 4 hours

Figure 7 illustrates a suitable bin, and Figure 8 illustrates a suggested arrangement for the bin room.

248.1 — Bin loading

It is assumed that each bin is loaded with approximately 3/4 hour's production (or 1400 pounds of product). After the bins are loaded, they are connected to the hot-air duct to accomplish the final drying.

248.2 — Bin operating

It is anticipated that twelve bins will provide adequate capacity for plant production, on the basis of six bins in the process of drying, one bin being loaded, one bin being unloaded, and four bins for holding. Space is provided for a total of six bins on the heated-air duct.

248.3 — Bin unloading

For unloading, one side of a bin is lifted by an electric hoist and the contents dumped into the hopper feeding the screening operation.

250 — Screening and Inspecting

251 — Elevating

The dehydrated potatoes are elevated from the hopper (248.3) to the screen by means of a goose-neck conveyor.

252 — Screening

Military specifications require that not more than one percent by weight of the dehydrated product may pass through a U. S. Standard sieve containing 8 meshes to the inch (0.0937 inch openings). Screening is therefore necessary to remove material that is too fine in size to comply with these requirements. In some plants, a magnet is provided at this point to remove metallic iron and steel contamination of the dried product.

255 — Inspecting

After being screened, the product is inspected for discolored pieces and other imperfections. The inspection is done while the screened dehydrated product is carried along a continuous conveyor belt going to the packaging operation.

260 — Packaging and Packing

261 — Filling, packing, and sealing

In this plant, the rate of handling cans (520 per hour) is low, and expensive automatic equipment to fill and weigh the cans is not justified.

In the proposed filling operation, cans are fed manually into the can-run and then automatically placed in register with the can-filling openings. The entire can-carrying circular table revolves, as well as the center bowl carrying the product to be packaged. The product is manually brushed into the filling openings by the operators. The feed bowl is supplied from an overhead hopper.

The filled cans are conveyed from the filling machine past two manual weighing stations and from there to a conventional can-closing machine. Specifications require that a printed leaflet giving cooking directions be placed in each can, or the directions be incorporated as part of the label on the exterior of the can.

Cans should be purchased with lithographed labels as required in the specifications. The date is stamped on each can at the time of packing.

262 — Case forming, filling, sealing, and marking

Military specifications permit the use of either wood boxes or fiberboard cartons of definite types; the military bids and contracts will specify the exact types of packing to be supplied by the dehydrator. Present-day dehydrators use either mechanical or manual casing methods. Mechanical case-sealing has been provided in the proposed plant.

270 — Warehousing and Shipping

In keeping with the current trend, the proposed plant utilizes pallets for handling and storing of the finished product in the warehouse.

ENERAL FACILITIES

The requirements for other needed facilities have been discussed in Volume I, nd the information will not be repeated here. The principal "general" facilities for he potato dice plant are listed in the "Cost of Facilities" for the proposed plant; ncluded are items for utilities, maintenance and repairs, inspection and control, iscellaneous plant facilities, automotive, and administrative facilities and supplies.

325 — Waste disposal

The waste material from the preparation line is conveyed into an overhead hopper. This hopper should be located to permit trucks to back under the discharge chute to remove the trimmings.

The liquid waste from the potato dehydration plant will be screened to remove the major part of the suspended waste solids. The screened liquid waste may be run into sewers, streams, irrigation ditches, seepage ponds, lagoons, or waste land, depending upon what is available and upon local or State regulations.

BUILDINGS AND GROUNDS

Buildings and grounds for a potato dehydration plant should conform with the general requirements described in Volume I under "Plant Location" and "Selection of Plant Procedures and Facilities". A minimum of three acres of land should be provided for the potato dice plant depicted herein; more acreage would be advisable in many cases.

Figure 3 shows a suggested plant layout. The raw potato storage cellar may be expanded away from the plant proper without interfering with the processing line. The various processing functions are located to permit expansion if such a step is necessary. Bin-drying, inspection, and packaging operations could expand outside the original building. Finished product storage area could expand in two directions. The tunnel-drying facilities could expand outside the building, the original design being such as to permit almost any number of tunnels to be added. Space for additional storage of trucks and trays could be provided in an extension of the building.

The boiler room is located in a corner of the main building. This location allows accessibility for servicing and repairing the boilers, and allows for expansion of the boiler room away from the plant proper, if desired.

The locations of the offices, laboratory, rest rooms, and lunch room are only suggestive. These could be rearranged without seriously affecting plant operations.

Floor drains should be provided in the preparation area — particularly under the washers (Code 221 and 223.9), trimming tables (Code 224), blancher (Code 227), along the tray loading and weighing line, and for each of the transfer tracks.

CHAPTER IV

COST OF POTATO DICE DEHYDRATION FACILITIES

Cost Summary

200 -- MANUFACTURING OPERATIONS FACILITIES		
210 -- "Raw Material Handling" Equipment	$18,440	
220-230 -- "Preparing" Equipment	71,850	
240 -- "Drying" Equipment	94,085	
250 -- "Screening & Inspecting" Equipment	4,135	
260 -- "Packaging & Packing" Equipment	12,770	
270 -- "Warehousing & Shipping" Equipment	8,445	
Total for MANUFACTURING FACILITIES		$209,725
GENERAL FACILITIES		
320 -- "Utilities" Equipment	$39,620	
330 -- "Maintenance and Repairs" Equipment & Supplies	15,000	
380 -- "Inspection and Control" Equipment & Supplies .	5,000	
390 -- "Miscellaneous Plant" Equipment	5,700	
400 -- "Automotive" Equipment	3,500	
690 -- "Office & First Aid" Equipment & Supplies . . .	5,000	
Total for GENERAL FACILITIES		$ 73,820
Total for Plant Equipment (TABLE I)		283,545
Total for Buildings & Grounds (TABLE II)		210,000
Construction Engineering Fees		30,000
TOTAL COST FOR ITEMIZED PHYSICAL FACILITIES FOR POTATO DICE DEHYDRATION PLANT		$523,545

Critical Materials in the Equipment for a 100-Ton Per Day Potato Dice Dehydration Plant

Material	Estimated Total No. of Pounds in Equipment	Percentage of Total Weight of Critical Materials
Iron and Steel	241,500	98.19
Copper	1,500	0.61
Stainless Steel	1,400	0.57
Zinc	600	0.24
Tin	100	0.06
Rubber	800	0.33
	245,900	100.00

Disclaimer Statement

The designation of any manufacturer or brand-name equipment does not imply a specific recommendation by the Department of Agriculture. Such inclusion means only that these particular items have been found satisfactory for the purpose indicated; other sources and items may prove equally satisfactory. Additional information concerning suggested manufacturers of equipment may be found in "Additional Sources of Information" (Volume I, Appendix C).

TABLE I — PLANT EQUIPMENT FOR A 100-TON PER DAY POTATO DICE DEHYDRATION PLANT
LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
		200 -- MANUFACTURING OPERATIONS FACILITIES				
210 -- Raw Material Handling						
211 -- Weighing (at plant)						
a.	Truck scales: To weigh incoming loads of raw material (not required for plants having access to public scales)	Fairbanks-Morse Code 6512 (13,700 lbs)	Platform 60' x 10', capacity 50 tons; equipped with type registering beam; includes structural steel for timber deck. Cost includes $350 installation charge, and does not include pit	1	$ 3,750	$ 3,750
b.	Pit & housing for scales	--	Estimated cost for constructing pit and housing for scales	-	--	3,000
213 -- Feeding to line						
a.	Elevator: To elevate potatoes from the recessed floor conveyor belt to the sorting belt	FMC 1/ Fig. 5071 (1,100 lbs)	All steel construction; feed hopper; elevator and draper (24" wide x 9' discharge height) constructed of steel slats carried by side chain; complete with 1-1/2 h.p. motor	1	2,035	2,035
b.	Recessed floor conveyor belt: To move potatoes from distant points in the cellar to the elevator	FMC Fig. 5031 (2,800 lbs)	30" wide x 80' long (center-to-center); rubber belt conveyor; steel frame; belt supported by oil-less bronze bearing rollers; complete with 2 h.p. motor drive	1	3,935	3,935
214 -- Sorting						
b.	Sorting belt: To inspect and pick out the "rots", "stones", and other extraneous matter from the potatoes	FMC Fig. 580 (1,100 lbs)	36" wide x 10' long (center-to-center); rubber belt conveyor; steel frame; belt supported by steel rollers; complete with 1 h.p. motor drive	1	1,090	1,090
b.	Washer-elevator: To elevate potatoes from the discharge end of the cellar inspection belt to the rod washer and partially wash and soften adhering dirt from potatoes	FMC Fig. 8657 (1,000 lbs)	12" wide x 15' discharge height; cleated rubber belt elevator with steel frame; complete with 1 h.p. motor drive	1	1,430	1,430
			Sub-total			$ 15,240
Allowance for Freight Charges (factory-made equipment) -- 20,000 lbs. at 5¢/lb.						1,000
Allowance for Installation Charges -- 25% of equipment cost plus freight ($8,790)						2,200
	Total Cost of "Raw Material Handling" Equipment					$ 18,440
220-230 -- Preparing						
221 -- Washing						
a.	Washer: To wash dirt from potatoes	FMC Fig. 9331 (2,300 lbs)	43" diameter x 12' long, rotary rod type washer, all-steel construction; with centrally located spray pipe and adjustable discharge baffle; complete with 2 h.p. splash-proof motor drive	1	3,000	3,000
222 -- Preheating						
a.	Preheater: To preheat the potatoes before peeling	Custom built 2/ (See Fig. 9) (6,500 lbs)	8 ft. o.d. x 6 ft. i.d. x 5 ft. long, rotary heater, equipped with direct steam injection heating; geared to rotate at a speed of approximately 20 minutes per revolution; complete with a 1 h.p. motor and variable drive	1	4,300	4,300
b.	Controls: To regulate and control temperatures in the preheater	Taylor #86RV323 #6VP255 #R89S17 #R41S323 (125 lbs)	Control set consisting of: Indicating temperature controller Reverse-acting diaphragm valve (1-1/4") Air filter Air reducing valve (1/4")	1	265	265
c.	Elevator: To elevate potatoes from the washer to the preheater	FMC Fig. 5071 (1,520 lbs)	24" wide x 12' discharge height standard elevator; all steel construction with slats and flight draper carried by side chains; complete with 1-1/2 h.p. motor drive	1	2,170	2,170

1/ Food Machinery & Chemical Corporation
2/ Southern Regional Research Laboratory (U.S.D.A.) design, as modified and specified by Benner-Nawman, Inc.

(Table I Continued)

LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
223 -- Peeling						
223.2 -- Lye peeling						
a.	Lye peeler: To loosen or remove skins from the potatoes	Custom built 2/ (See Fig. 9)	6 ft. o.d. x 4 ft. i.d. x 5 ft. long, rotary peeler equipped with steam-heating coils; geared to rotate at speeds ranging from 7-1/2 to 15 minutes per revolution; complete with 1 h.p. motor	1	$3,800	$ 3,800
b.	Lye make-up tank: To dilute the concentrated lye solution to proper strength for feeding to the lye peeler	Custom built (250 lbs)	4' diameter x 6' high cylindrical steel tank; nominally 500 gallon capacity; equipped with valve	1	100	100
b.	Lye storage tank: To store concentrated caustic soda solution	Standard construction (12,000 lbs)	15,000 gallon capacity; for underground storage with pump, piping and accessories	1	2,000	2,000
c.	Lye peeler temperature controls: To control steam pressure in the heating coils in order to maintain proper temperatures	Taylor #86RV323 #6VP255 #R89S17 #R41S323 #12EU310 (125 lbs)	Control set consisting of: Indicating temperature controller; Reverse-acting diaphragm valve (1-1/4"); Air filter; Air reducing valve (1/4"); Thermometer (30° F. to 240° F.	1	275	275
223.9 -- Washing						
a.	Washer: To wash the potatoes free from adhering skins and caustic	FMC Fig. 9331 (2,300 lbs)	43" diameter x 12' long, rotary rod-type washer; all steel construction; with centrally located spray pipe, with adjustable discharge baffle; complete with 2 h.p. splash-proof motor drive	1	3,000	3,000
c.	Elevator: To elevate peeled potatoes to washer	FMC Fig. 5071 (1,000 lbs)	24" wide x 6' discharge height, standard elevator; all steel construction, with steel slats and flight draper carried on side chains; complete with 1-1/2 h.p. motor drive	1	1,900	1,900
224 -- Trimming and inspecting						
a.	Conveyor belt: To move washed potatoes from the washer and convey and distribute them to trimming belts	FMC Fig. 5030 (1,000 lbs)	24" wide x 15' long, center-to-center, rubber belt distributing conveyor; steel frame construction; belt supported by steel rollers complete with 1-1/2 h.p. motor drive	1	1,385	1,385
b.	Trimming belts: To supply washed and peeled potatoes for final hand trimming	FMC Fig. 9318 (4,000 lbs each)	Merry-go-round trim tables consisting of 3 parallel 12" wide x 30' long (center-to-center) rubber belt conveyors; outer belts for trimming and with divided lanes for trimmings; inner belt to be raised so that return side acts as merry-go-round return for overflow from outer belts, top side for conveying trimmed product to discharge point; all steel frame construction with belts carried on steel rollers; complete with 3 h.p. motor drive	2	4,455	8,910
e.	Conveyor belt: To collect trimmed potatoes and convey to elevator feeding dicers	FMC Fig. 5030 (1,100 lbs)	24" wide x 17' long (center-to-center) rubber belt conveyor; steel frame construction; belt supported by steel rollers; complete with 1-1/2 h.p. motor drive	1	1,475	1,475
226 -- Cutting (dicing)						
a.	Elevator: To elevate trimmed potatoes to the dicers	FMC Fig. 8657 (1,550 lbs)	24" wide x 13' discharge height, standard elevator; cleated rubber belt elevator with steel frame; complete with 1/2 h.p. motor drive	1	2,210	2,210
b.	Cutters (dicers): To cut prepared potatoes to 3/16" x 3/8" x 3/8" size	Urschel Model B (750 lbs each)	Standard dicer with one extra slicing knife, 6 extra circular knives and 6 extra cross-cut knives; complete with 2 h.p. splash-proof motor drive	3	1,410	4,230

2/ Southern Regional Research Laboratory (U.S.D.A.) design, as modified and specified by Benner-Nawman, Inc.

(Table I Continued)

LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
227 -- Blanching and sulfiting						
b.	Blancher: To blanch the diced product before drying	FMC Fig. 9332 (11,000 lbs)	Steam blancher, 7' wide x 50' overall dimensions; with 6' wide stainless steel woven wire draper; with spray sections at feed and discharge ends; complete with 5 h.p. variable speed motor drive	1	$14,700	$ 14,700
c.	Sulfite make-up equipment: (1) Tanks: To mix and hold sulfiting solutions	Standard model (500 lbs ea)	500 gallon fir wood tank, 4' high	2	100	200
	(2) Sulfite pump: To deliver sulfite solution from storage to spray nozzles at sulfiting end of blancher	Tri-Clover Model 1-CR (100 lbs)	Centrifugal type sanitary pump, 1-1/4" x 1"; bronze; complete with 1/2 h.p. motor	1	110	110
e.	Controls: To regulate and control temperature in the blancher	Taylor #86RV323 #6VP255 #R89S17 #R41S323 #12EU310 (125 lbs each set)	Each control set consisting of: Indicating temperature controller; Reverse-acting diaphragm valve (1-1/4"); Air filter; Air reducing valve (1/4"); Thermometer (120° F. to 220° F.)	2	275	550
			Sub-total			$ 54,580
Allowance for Freight Charges (factory-made equipment) -- 58,000 lbs. at 5¢/lb.						2,900
Allowance for Installation Charges -- 25% of equipment cost plus freight ($57,480)						14,370
Total Cost of "Preparing" Equipment						$ 71,850
240 -- Drying						
241 -- Tunnel drying						
241.1 -- Tray loading						
a.	Tray conveyor: To convey empty trays under blancher to tray loader and tray stacker	Custom built (2,000 lbs)	6' wide x 25' long (center-to-center), double drag chain conveyor; complete with 2 h.p. variable speed motor drive	1	2,300	2,300
b.	Tray spreader: To load (and spread uniformly) the blanched potatoes on the drying trays	Syntron Model F44 "Twin" (5,000 lbs)	Two - 36" stainless steel troughs; with magnetic vibrators	1	2,000	2,000
241.2 -- Tray stacking						
a.	Tray stacker: To stack loaded trays on cars	Knipschild Model (4,000 lbs)	Loaded trays are lifted vertically from tray conveyor and moved horizontally until positioned over empty car, then stacked to a height of 25 trays; fully automatic	1	3,600	3,600
241.3 -- Weighing						
a.	Scales: To weigh loaded cars	Toledo Model 31 1921 FE -- 76 x 54 FF (1,875 lbs)	Dial-type indicating system, 2,600 lbs. capacity; platform 76" x 54"; equipped with extension lever to permit location of dial column out of path of cars; installed in pit with the scale-platform level with floor	1	980	980
241.4 -- Tunnel operating						
a.	Trays: To hold diced potatoes while in the tunnel driers	--	6' long x 3' wide; wood frame and slat construction	3,200	3	9,600
b.	Tunnel driers: To dry potato dice to approximately 10% moisture	(See Figures 5 and 6)	Twin tunnel, single stage, counter-flow, 12-car length; equipped with necessary control equipment, trackage, cars, blower, furnace, etc.	4 twin tunnels	--	65,000 3/
241.5 -- Tray unloading and stacking						
a.	Tray scraper: To remove dried potato dice from trays	Knipschild (1,500 lbs)	Trays are manually removed from cars and turned over a revolving wire brush which loosens the potato dice; potato dice falls into hopper	1	1,400	1,400

3/ Cost installed - based on estimates from Bloxham Engineering Co., Basalt Rock Co., and other sources.

(Table I Continued)

LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
241.6	-- Elevating and conveying					
a.	Elevator: To elevate dried potato dice from discharge end of tray unloading hopper to bin loading hopper	FMC Fig. 542 (1,360 lbs)	Gooseneck conveyor, discharge height 10', 16" wide buckets; complete with 1 h.p. motor drive	1	$ 820	$ 820
			Sub-total			$ 85,700
Allowance for Freight Charges (factory-made equipment)			--16,000 lbs. at 5¢/lb.			800
Allowance for Installation Charges -- 25% of equipment cost plus freight (11,900)						2,975
	Total Cost of "Tunnel Drying" Equipment					$ 89,475
248 -- Bin drying						
248.1	-- Bin loading					
a.	Portable bins: To hold potato dice during the final drying stage	Custom built (See Fig. 7)	3' wide x 5' long x 5' high; sheet metal, or plywood construction; mounted on casters and equipped with ring for dumping by means of a hoist; metal screen to serve as a false bottom; 12" diameter air duct	12	$ 65	780
248.2	-- Bin operating					
b.	Blower: To circulate air through heating coils and drying bins	Sturtevant Silentvane No. 80 Design 10 Class II (875 lbs)	Single width; bottom horizontal discharge; 10,000 c.f.m. at 5" s.p.; equipped with 15 h.p. motor drive	1	1,000	1,000
c.	Heating coils: To heat air going into drying bins	Aerofin Corp. Type F Non-Freeze Coil Series 80 (400 lbs)	Bank of coils, 3 rows deep, consisting of one section 24 tube face, 4' tubes (No. 82), plus one section ditto (No. 81)	1	600	600
d.	Ductwork: To carry air from outside of building, conduct it through the fans and heating coils and to each of the 6 drying bin positions	Custom built	Horizontal run laid on floor; 35' long, 10 sq. ft., cross-sectional area; 6 outlets on vertical side face spaced 5' apart; each outlet with transition to 12" diameter collar	1	1,250	1,250
248.3	-- Bin unloading					
a.	Hoist: To elevate the drying bins for dumping of the dried potatoes	Yale Midget King Electric Hoist Model No. 1E 17 H (140 lbs)	Hook type; 2,000 lbs. capacity; 10' lift; 17 f.p.m.; 1 h.p.	1	360	360
			Sub-total			$ 3,990
Allowance for Freight Charges (factory-made equipment)			-- 2,000 lbs. at 5¢/lb.			100
Allowance for Installation Charges -- 25% of equipment cost plus freight ($2,060)						520
	Total Cost of "Bin Drying" Equipment					$ 4,610
	Total Cost of "Tunnel Drying" Equipment					89,475
	Total Cost of "Drying" Equipment					$ 94,085
250 -- Screening and Inspecting						
251 -- Elevating						
a.	Elevator: To elevate product from hopper to shaker screen	FMC Fig. 542 (1,300 lbs)	Gooseneck conveyor; discharge height 8'; 16" wide buckets; 1 h.p. motor drive	1	$ 775	$ 775
252 -- Screening						
a.	Magnet: To remove tramp iron from product	FMC (Cesco) Plate Magnet (20 lbs)	Steel face plate 12" wide; standard model	1	90	90
b.	Shaker screen: To screen out "fines" from dried products	Link-Belt UP #125 (870 lbs)	2' x 5' unbalanced pulley type; one screen section on single deck; 2 h.p. motor drive	1	600	600

(Table I Continued)

LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
255 -- Inspecting						
b.	Conveyor-sorter: To convey the product past the final inspection station	FMC Fig. 5031 (1,300 lbs)	30" wide x 16' long (center-to-center) white rubber belt; steel frame construction; 1 h.p. motor drive	1	$1,640	$ 1,640
			Sub-total			$ 3,105
Allowance for Freight Charges (factory-made equipment) -- 4,000 lbs. at 5¢/lb.						200
Allowance for Installation Charges -- 25% of equipment cost plus freight ($3,305)						830
	Total Cost of "Screening and Inspecting" Equipment					$ 4,135
260 -- Packaging and Packing						
261 -- Filling, packing and sealing						
a.	Elevator: To elevate product to can-filling equipment	FMC Fig. 542 (1,000 lbs)	Gooseneck conveyor-elevator; discharge height 6'; 16" wide buckets; 1 h.p. motor drive	1	$ 755	$ 755
c.	Filling machine: To fill the product into No. 10 cans	FMC Handpack Filler Fig. 460-10 (1,500 lbs)	Product is fed into a hopper which rotates with the can carrying table; stainless steel construction where in contact with product; complete with 1 h.p. motor drive and motor-driven vibrator	1	1,815	1,815
c.	Scales: To check-weight exact amounts into cans	FMC Fig. 2150 (55 lbs ea)	Model 10-72-05 Detectogram general purpose scale; 10 lbs. capacity	2	115	230
g.	Closing machine (seamer): To seal covers on cans	American Can Co. (No. 1) (1,050 lbs)	Semi-automatic machine operated by depressing foot treadle for each seaming operation; includes 1-1/2 h.p. motor drive	1	850	850
h.	Conveyor: To convey filled cans past weighing station and to can-closing machine	FMC Special attachment to Can Filler (300 lbs)	7" wide x 8' leather belt conveyor	1	500	500
262 -- Case forming, filling, sealing and marking						
a.	Case branding machine: To print required markings on cases	FMC Fig. 8072 (2,225 lbs)	Automatic machine equipped to handle box shook and flat fibre cases; complete with 1 h.p. motor and variable speed drive	1	1,980	1,980
b.	Case sealing machine: To seal top and bottom flaps on cases	Elliott Model A (4,000 lbs)	Fully automatic with 16' of compression section; complete with 3/4 h.p. motor drive on gluing section and 1/4 h.p. motor on compression section	1	3,535	3,535
			Sub-total			$ 9,665
Allowance for Freight Charges (factory-made equipment) -- 11,000 lbs. at 5¢/lb.						550
Allowance for Installation Charges -- 25% of equipment cost plus freight ($10,215)						2,555
	Total Cost of "Packaging and Packing" Equipment					$ 12,770
270 -- Warehousing and Shipping						
271 -- Palletizing						
a.	Pallets: For handling empty cans and filled cases	Custom built	Wood construction; 48" x 60"; double-faced	1,000	4	4,000
272 -- Warehousing						
a.	Lift truck: To move palletized loads in products warehouse	Yale Model KG-51-T-40-U (7,300 lbs)	Capacity 2 tons; gasoline engine	1	4,080	4,080
			Sub-total			$ 8,080
Allowance for Freight Charges (factory-made equipment) -- 7,300 lbs. at 5c/lb.						365
Allowance for Installation Charges						none
	Total of "Warehousing and Shipping" Equipment					$ 8,445
	TOTAL COST OF "MANUFACTURING OPERATIONS" FACILITIES					$209,725

(Table I Continued)

LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
			GENERAL FACILITIES			
320 -- Utilities						
321 -- Water supply						
a.	Water pump: To elevate water from well and to deliver it throughout plant at required pressure	Peerless Deepwell Turbine-Type Pump (5,300 lbs)	8 stage, 10" M.A., Sheet No. R-1096, Curve 1; 500 g.p.m. with 285 ft. head at 80 p.s.i. delivery pressure; complete with strainer and 40h.p. motor	1	$2,000	$ 2,000
b.	Chlorinator: To treat the water used in the plant to prevent slime formation and improve plant sanitation	Wallace & Tiernan Type MASVM-A-421 (1,500 lbs)	Consists of chlorinator, booster pump, differential converter and main line orifice place; converter automatically controls flow of chlorrine so that the latter is always proportional to the flow of water; with 5 h.p. (electric) motor	1	4,500	4,500
c.	Water well: For supplying water sufficient to meet needs of the plant	--	Cost includes drilling and casing of well and small housing for pump motor	1	3,000	3,000
322 -- Oil storage tanks						
b.	Fuel supply: To store fuel oil for steam boiler and drying-tunnel operations	Standard construction (12,000 lbs each)	15,000 gallon capacity; for underground storage; with pump, piping, and accessories	3	2,000	6,000
324 -- Steam supply						
a.	Steam boiler: To supply steam for operation of plant equipment, clean-up, building heating, etc.	Cleaver-Brooks Model LR-600-15 (21,200 lbs)	Four-pass horizontal fire-tube boiler with integral channel iron frame and burner assembly; 150 boiler horsepower rating; 125 p.s.i. design pressure; equipped for burning #6 oil; complete package unit	1	8,750	8,750
325 -- Waste disposal						
a.	Sewage screen: To separate solids from water in sewage disposal system	FMC Fig. 1437 North Sewage Screen (8,000 lbs)	Trunion type, with segment tooth drive; 6 ft. screen, No. 20-mesh bronze wire; 400 g.p.m. capacity; complete with steel tank and 3 h.p. motor drive	1	3,095	3,095
b.	Elevator: To elevate solid waste from sewage screen to hopper	FMC Fig. 541 (2,100 lbs)	12" wide, gooseneck conveyor-elevator with galvanized iron buckets; discharge height 20 feet; complete with 1 h.p. motor drive	1	880	880
c.	Hopper: To hold solid waste until trucked to dump	Custom built	10' long x 10' wide x 6' height; with sloping sides and discharge gate; elevated clearance 12 feet	1	400	400
			Sub-total			$ 28,625
Allowance for Freight Charges (factory-made equipment) -- 75,000 lbs. at 5¢/lb.						3,750
Allowance for Installation Charges -- 25% of equipment cost plus freight ($28,975)						7,245
	Total Cost of "Utilities" Equipment					$ 39,620
330 -- Maintenance and Repairs 4/						
a.	Maintenance shop equipment: To maintain plant in proper operating condition; to make necessary repairs	--	Includes welding and cutting equipment; drill presses; cut-off saws; sheet metal cutting facilities; hand tools for carpentry, electrical, and metal work; pipe threading and cutting equipment; miscellaneous supplies	-	--	5,000
b.	Maintenance parts and supplies: Standing inventory of spare parts and maintenance supplies to assure continuous operation of plant	--	Pipe, sheet metal, fittings, electric motors, equipment parts, welding supplies, etc.	-	--	10,000
	Total Cost of "Maintenance and Repairs" Equipment and Supplies					$ 15,000

4/ Costs indicated for these items include installation costs

(Table I Continued)

LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
380 -- Inspection and Control 4/						
381 -- Laboratory testing						
a.	Laboratory equipment and supplies: To do necessary control testing of processing operations and of finished products	--	Apparatus, supplies, tables, books, benches, and other facilities needed for tests and control purposes	-	--	$ 5,000
	Total Cost of "Inspection and Control" Equipment and Supplies					$ 5,000
390 -- Miscellaneous Plant Equipment 4/						
a.	a. Lunch room: To accomodate up to 50 people at a time	--	--	-	--	$ 4,500
b.	Fire-fighting equipment: For emergency use	--	2 - 300 ft. hoses & reels; 2 emergency showers; 8 - 5 gal. extinguisher tanks; 12 hand extinguishers; 12 gas masks	-	--	1,200
	Total Cost of "Miscellaneous Plant" Equipment					$ 5,700
400 -- Automotive Equipment						
a.	Truck: For miscellaneous hauling	GMC	1-1/2 ton pick-up truck (delivered price)	1	$ 3,500	$ 3,500
	Total Cost of "Automotive" Equipment					$ 3,500
690 -- Miscellaneous Administrative Supplies and Facilities 4/						
a.	Office furniture, supplies, and first-aid facilities: For bookkeeping, pay rolls, personnel work, business transaction, first aid, etc.	--	--	-	--	$ 5,000
	Total Cost of "Miscellaneous Administrative Supplies & Facilities"					$ 5,000
	TOTAL COST OF "GENERAL" FACILITIES					$ 73,820

TABLE II

BUILDINGS AND GROUNDS FOR A POTATO DICE DEHYDRATION PLANT

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
	Building & Grounds: Suitable building and grounds for the potato dice dehydration plant	--	Includes: land; a building complete with industrial lights, utility and sewer lines within the building, toilet facilities and loading ramps (or platform)			
			Building -- 42,000 sq. ft. at $5/sq. ft.			$210,000
	TOTAL COST OF BUILDING AND GROUNDS					$210,000

TABLE III

OPTIONAL EQUIPMENT FOR A POTATO DICE DEHYDRATION PLANT

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
321 -- Water supply						
a.	Diesel engine: For standby use for operating the well water pump	Fairbanks Morse Co.	Diesel engine complete with fuel tank and connecting gears for attaching to well water pump. Cost for this standby service is in addition to the cost of pump equipment listed	1	$ 1,500	$ 1,500
394 -- Miscellaneous 5/						
a.	Hand trucks, auxiliary tables and other similar equipment	--	--	-	--	$ 5,000
	TOTAL COST FOR "OPTIONAL" FACILITIES					$ 6,500

5/ Delivered cost

Chapter V

PRODUCTION COSTS
FOR A 100-TON PER DAY POTATO DICE DEHYDRATION PLANT

Table I -- Summary of Costs of Producing Dehydrated Potato Dice
(Assuming Different Raw Material Costs and Shrinkage Ratios)

Overall-shrinkage ratio of:			6 to 1	7 to 1	9 to 1
Output of finished product per day (lbs.)			33,340	28,600	22,220
			Production Cost per Pound of Product		
Processing Cost - See Table II			$0.1749	$0.1914	$0.2249
Assumed Cost per 100 tons of Raw Material Entering Processing Line					
	At $10 a ton	$1,000 a day	$0.0300	$0.0350	$0.0450
	20	2,000	0.0600	0.0700	0.0900
	30	3,000	0.0900	0.1050	0.1350
	40	4,000	0.1200	0.1400	0.1800
	50	5,000	0.1500	0.1750	0.2250
	60	6,000	0.1800	0.2100	0.2700
Assumed Production Cost at Various Costs of Raw Material 1/					
	At $10 a ton		$0.2049	$0.2264	$0.2699
	20		0.2349	0.2614	0.3149
	30		0.2649	0.2964	0.3599
	40		0.2949	0.3314	0.4049
	50		0.3249	0.3664	0.4499
	60		0.3549	0.4014	0.4949
Estimated Depreciation Charges (See Table X)					
	Normal Life Expectancy		$0.0034	$0.0039	$0.0050
	Accelerated Write-off		0.0118	0.0137	0.0177

1/ Exclusive of Depreciation Charges

Table II -- Processing Cost Summary Using 3 Different Overall Shrinkage Ratios
(Depreciation not included)
(Potato Dice Dehydration Plant)

	6 to 1 (Low)	7 to 1 (Average)	9 to 1 (High)
Input - lbs. per day raw commodity	200,000	200,000	200,000
Output - lbs. per day potato dice (7% moisture)	33,340	28,600	22,220
Total daily processing cost based upon cost calculation using a 7 to 1 overall shrinkage ratio	$5,475	$5,475	$5,475
Adjustment for labor -			
Deduct 22% of labor cost of screening and inspecting, packaging and packing, and warehousing and shipping ($472)			- 104
Add 17% of labor cost of screening and inspecting, packaging and packing, and warehousing and shipping ($472)	+ 80		
Adjustment for packaging supplies -			
Deduct total packaging supply cost based on a 7 to 1 ratio (see Table III)	- 1,671		- 1,671
Add cost applicable to shrinkage ratio (pounds x $0.0584)	+ 1,947		+ 1,298
Adjusted cost 1/	$5,831	$5,475	$4,998
Cost per pound of net product	$0.1749	$0.1914	$0.2249

1/ For purposes of this illustration, it is assumed that all costs per day would be constant for the various yields except the two cost items adjusted. In actual practice, however, costs would be more variable as a result of the different shrinkage ratios

Table II-A -- Calculation of Unit Costs of Processing for Various Shrinkage Ratios
(Assuming constancy of cost except as calculated in Table II)

	6 to 1		7 to 1		9 to 1	
	Daily Cost	per Pound	Daily Cost	per Pound	Daily Cost	per Pound
Pounds output per day	33,340		28,600		22,220	
Raw material procurement	$ 77	$0.0023	$ 77	$0.0027	$ 77	$0.0035
Direct labor cost	2,074	0.0622	1,994	0.0697	1,890	0.0850
Manufacturing expense	3,280	0.0984	3,004	0.1050	2,631	0.1184
Packaging supplies and expenses	1,947	0.0584	1,671	0.0584	1,298	0.0584
Other manufacturing expenses	1,333	0.0400	1,333	0.0466	1,333	0.0600
General and Administrative Expenses	400	0.0120	400	0.0140	400	0.0180
Total	$5,831	$0.1749	$5,475	$0.1914	$4,998	$0.2249

Table III -- Processing Cost Summary for Potato Dice Dehydration Plant

Account No.	Table No. Reference	Processing Cost Per 24-Hour Operating Day	Processing Cost Per Pound Dry Product
Output of Finished Product per Day . . . . (7 to 1 overall shrinkage ratio)	II	28,600 pounds	
800 -- Total Cost of Finished Product . . . . . . (exclusive of depreciation and raw material purchase price)		$5,475	$0.1914
100 -- Raw Material Cost . . . . (exclusive of purchase price)	IV	$ 77	$0.0027
120 - Buying Expense		47	0.0016
180 - Federal-State Inspection		30	0.0011
200 -- Direct Labor	V	$1,994	$0.0697
210 - Raw Material Handling		142	0.0050
220-230 - Preparing		999	0.0349
240 - Drying		381	0.0133
250 - Screening and Inspecting		243	0.0085
260 - Packaging and Packing		184	0.0064
270 - Warehousing and Shipping		45	0.0016
300 -- Manufacturing Expenses		$3,004	$0.1050
310 - Indirect labor	VII	172	0.0060
320 - Utilities	VIII	668	0.0234
330 - Maintenance and Repairs	IX	164	0.0057
340 - Depreciation (not included)	X	---	------
350 - Taxes and Insurance	XI	66	0.0023
370 - Packing Supplies & Expenses	XII	1,671	0.0584
380 - Inspection and Control	XIII	72	0.0025
390 - Miscellaneous Plant Expenses	XIV	191	0.0067
600 -- General and Administrative Expenses . . .	XV	$ 400	$0.0140
610 - Office Salaries		159	0.0056
620-690 - Miscellaneous Expenses		241	0.0084

Table IV -- Raw Material Cost (Account 100)
(Potato Dice Dehydration Plant)

Account No.		Annual Cost	Cost per Operating Day 1/
100 -- Total Raw Material Cost (excluding purchase price of raw material)		$15,456	$77
110 - Purchase Price		------	---
The purchase price of raw material is not included here as a cost. See Table I for calculation of raw material costs at various purchase prices per ton			
120 - Buying Expense		9,456	47
Salary of field agent	$7,000		
Social security, workmen's compensation and unemployment insurance - 6.52%	456		
Expense, travel, telephone, etc. (estimated)	2,000		
150 - Transportation and Weighing Costs		------	---
Included in Table I as part of assumed prices paid for raw material			
160 - Storage		-----	---
No outside storage costs are assumed for this study. It is further assumed that the purchase price of raw material includes outside storage costs			
170 - Crate, Box, and Sack Expense		-----	---
Assumed potatoes will be handled in bulk			
180 - Federal-State Inspection		6,000	30
One inspector 200 days at $30			

1/ Annual cost divided by 200 (number of working days)

Table V -- Direct Labor Cost Summary (Account 200)
(Potato Dice Dehydration Plant)

Account No.		Per 24-Hour Operating Day: Direct Labor Cost per Day 1/	Add Labor Expense 24% 2/	Total Direct Labor Cost
200	-- Total Direct Labor Cost	$1,608	$386	$1,994
210	- Raw Material Handling	114	28	142
220-230	- Preparing	805	194	999
240	- Drying	308	73	381
250	- Screening and Inspecting	196	47	243
260	- Packaging and Packing	149	35	184
270	- Warehousing and Shipping	36	9	45

1/ From Table VI

2/ In addition to the "Direct Labor Cost per Day" the following items are additional costs that must be paid by the employer:

		Percentage to apply to calculated Labor Cost
a.	Overtime - All hours per week over 40 are paid for at one-and-one-half times the basic rate. The work week is 48 hours, making 8 hours to be paid at overtime. For the week he gets 52 hours pay for 48 hours work (52/48) - 1.0 = 0.08333	8.33%
b.	Swing and night shift differential may amount to 5¢/hr. At an average hourly labor rate of $0.92, the differential is 5.42% for each of 2 shifts, or an average of 3.62% on a three shift basis	3.62
c.	Social security - paid by employer	1.50
d.	Unemployment insurance - for a new, highly seasonal business, the rate would be	2.70
e.	Workmen's compensation insurance (based upon California rates)	2.32
f.	Vacation pay - A typical union contract provides for vacation with pay after the end of year in which an employee has worked 1600 hours or more. On an operation such as considered here, 200-day season, the employees would work 1600 hours and thus earn a week's vacation. Pay would be for a 48-hour week, the average time worked during the year. 48/1600 =	3.00
g.	Holiday pay - with 7 or 8 legal holidays in a year, there would be about 5 holidays in an 8-month operation. Since some union contracts provide for such pay, even when the employee does not work, allowance is made here for such cost	2.50
	Total (round off to)	24.00%

Table VI -- Direct Labor Cost Work Sheet (Account 200)
(Potato Dice Dehydration Plant)

Account No.	Operation	Number of Employees per Shift: Men	Number of Employees per Shift: Women	Hourly Rate of Pay: Pay Bracket	Hourly Rate of Pay: Amount	Total Hours per Shift	Total Cost per Shift	Total Cost per 24-Hour Operating Day
200 --	TOTAL DIRECT LABOR COST	17	57				$536.13	$1,608.40
210 --	Raw Material Handling	4 1/2	-				$ 38.00	$ 114.00
	Foreman 1/	1/2		1	$1.50	4	6.00	
	Feeding line	2		4	1.05	16	16.80	
	Sorting	1		5	.95	8	7.60	
	Cleaning up	1		5	.95	8	7.60	
220- - 230	Preparing	2 1/2	36				268.40	805.20
	Foreman 1/	1/2		1	1.50	4	6.00	
	Floorlady		1	5	.95	8	7.60	
	Trimming and inspecting		35	6	.85	280	238.00	
	Operating preheater, peeler and blancher	1		3	1.15	8	9.20	
	Cleaning up	1		5	.95	8	7.60	
240 --	Drying	6	8				102.53	307.60
241 -	Tunnel drying	4 1/2	8				88.13	264.40
	Foreman 2/	1/2		1	1.50	4	6.00	
	Feeding trays to tray loading		2	6	.85	16	13.60	
	Loading and spreading on trays		2	6	.85	16	13.60	
	Stacking trays & weighing trucks	1		4	1.05	8	8.40	
	Operating tunnels	2		4	1.05	16	16.80	
	Feeding tray scraper		2	6	.85	16	13.60	
	Restacking trays		2	6	.85	16	13.60	
	Sub-total	3 1/2	8				85.60	256.80
	Washing trays - Sunday only 3/	(5)		5	.95	40	38.00	
	Repairing trays - Sunday only 3/	(1)		5	.95	8	7.60	
	Sub-total - Sunday only	(6)					45.60	7.60
248 -	Bin drying	1 1/2	-				14.40	43.20
	Foreman 2/	1/2		1	1.50	4	6.00	
	Handling bins	1		4	1.05	8	8.40	
250 --	Screening and Inspecting	3/4	8 1/2				65.40	196.20
	Foreman 4/	1/4		1	1.50	2	3.00	
	Floorlady 5/		1/2	5	.95	4	3.80	
	Inspecting		8	6	.85	64	54.40	
	Attending screen and cleaning up 6/	1/2		4	1.05	4	4.20	
260 --	Packaging and Packing	2	4 1/2				49.60	148.80
	Foreman 4/	1/2		1	1.50	4	6.00	
	Floorlady 5/		1/2	5	.95	4	3.80	
	Feeding and filling cans		2	6	.85	16	13.60	
	Check-weighing cans		1	6	.85	8	6.80	
	Sealing and casing cans		1	6	.85	8	6.80	
	Sealing, branding, and stacking cases	1		4	1.05	8	8.40	
	Cleaning up (and attending screen) 6/	1/2		4	1.05	4	4.20	
270 --	Warehousing and Shipping	1 1/4	-				12.20	36.60
	Foreman 4/	1/4		1	1.50	2	3.00	
	Operating lift truck	1		3	1.15	8	9.20	

1/ One foreman for raw material handling and preparing
2/ One foreman for all drying operations
3/ Tray washing and repairing done on Sunday only - charge 1/6 of cost to each operating day
4/ One foreman for screening, packaging, and warehousing operations
5/ One floorlady for screening and packaging
6/ One cleanup man for screening and packaging

Table VII -- Indirect Labor (Account 310)
(Potato Dice Dehydration Plant)

Account No.	Number of Employ-ees	Assumed Yearly Rate	Hourly Rate	Total No. of Hours Employed Annually 1/		Yearly Cost	Cost per Operating day 2/
310 -- Total Indirect Labor						$34,370	$172
Year-round Employees						26,630	
Production Supt.	1	$7,000	-	-	$7,000		
Shift Superintendents	2	6,000	-	-	12,000		
Guards	---	-----	--	-	6,000 3/		
Labor expense - 6.52% 4/					1,630		
Seasonal Employees						7,740	
Boiler operator and oiler	3		$1.30	4,800	$6,240		
Labor expense 24% 5/					1,500		

1/ 1,600 hour season (1,600 x 3 = 4,800)

2/ Yearly cost of $34,370 divided by number of operating days, 200

3/ The estimate of $6,000 for guard service is based upon an assumption of 16 hours guard service per day for each day of the year. The number of guards actually employed will depend upon how the guard time is divided among the guards. For example, in a week of 7 days, 16 hours a day, or a total of 112 hours, three guards could divide the time so that each would work about 37 hours

4/

Social security	1.50%
Unemployment insurance	2.70
Workmen's compensation	2.32
	6.52%

5/ See Table V for analysis of 24% labor expense

Table VIII -- Utilities (Account 320)
(Potato Dice Dehydration Plant)

Account No.		Cost/Operating Day
320	-- Total Daily Cost of Utilities	$668
321	-- Water Supply	---
322	-- Fuel - Oil	582
323	-- Electric power	46
325	-- Waste disposal	40

321 -- Water Supply

400 gallons a minute is estimated need of plant. It is assumed the water will be pumped from company's own well, so cost of pumping is included in cost of power

322 -- Fuel - Oil

Tunnels — $508

Fuel oil requirements for drying tunnels:

Fuel (mixture of:)	60% #1 oil @ 13 3/4¢/gal.	8.25¢
	40% #2 oil @ 13¢/gal.	5.20¢
	Average cost/gal (delivered)	13.45¢
	Assume 13 1/2¢/gal.	

Temperature rise (average) from 30° to 160°F.
40,000 cu.ft. of air per minute per twin tunnel

$$\frac{(40{,}000 \times 60) \times (160^\circ - 30^\circ) \times .24}{15 \text{ cu.ft./lb.}} = 4{,}992{,}000 \text{ BTU/hr. per twin tunnel}$$

Approx. BTU/hr. for 4 twin tunnels	19,968,000
Add 10% for tunnel losses	1,996,800
Total BTU/hr.	21,964,800
Approx. BTU/24-hour operating day	527,000,000
Gallons of fuel oil (140,000 BTU/gal) per 24-hour operating day	3,765
Cost of oil (for tunnel operation) per 24-hour operating day @ 13 1/2¢/gal.	$508

Boiler — 74

Approx. fuel oil requirements for boiler operation:
Fuel #6 oil (delivered) @ 9 3/4¢/gal.
Boiler 75% load on 150 h.p. boilers with 80% efficiency
Fuel at 150,000 BTU/gal.

$$\frac{.75 \times 150 \times 33{,}500 \times 24}{.80 \times 150{,}000} = 754 \text{ gal/24 hours}$$

Approx. cost of oil per 24-hour operating day @ 9 3/4¢/gal = $74

323 -- Electric power

Motors - 250 h.p. (746 watts per h.p. and 75% use and efficiency factor)	140 K.W.
Lights - estimated at	50
190 K.W. x 24 = 24,560 K.W. per day	190 K.W.
24,560 K.W. @ $0.01 =	$45.60

325 -- Waste disposal

Garbage disposal
20 tons of wet waste per day at $2.00 a ton disposal cost = $40

Sewerage charges - none   Assume disposal in rural area

Table IX -- Maintenance and Repairs (Account 330)
(Potato Dice Dehydration Plant)

	Total No. of Employees	Hourly Rate Pay Bracket	Hourly Rate Amount	Hours Worked Process Season 1/	Hours Worked Off Season 2/	Total per Employee	Total for Group	Total Cost Per Year
Labor 3/								
Head mechanic	1	1	$1.50	1,600	760	2,360	2,360	$3,540
Shift mechanics and oilers	3	2	1.30	1,600	760	2,360	7,080	9,204
Maintenance mechanic	1	3	1.15	1,600	760	2,360	2,360	2,714
Sub-total	5							$15,458
Labor expense 15% 4/								2,319
Labor Cost								$17,777
Cost of Supplies and Replacements								
Estimated (for entire year)								15,000
Total cost of "Maintenance and Repairs" for a year								$32,777
Cost per operating day ($32,777/200)=							$163.90	

1/ 200 day operating season @ 8 hours = 1,600 hours

2/ 19 weeks, 95 days off-season - includes vacation time

3/ It is assumed all mechanics will be employed during off-season on maintenance and repair work

4/ Labor expense during processing season 18.88%

Night shift differential: 2 mechanics out of 5 on night shift. Average hourly rate of $1.31, 5¢ an hour differential (.05/1.31 x 2/5)	1.53%
Social security	1.50
Unemployment insurance	2.70
Workmen's compensation	2.32
Vacation pay (included in time for off-season)	----
Holiday pay (see Table V)	2.50
Overtime - 52 hours pay for 48 hours work (see Table V)	8.33

Labor expense during off-season 6.52%

Social security	1.50
Unemployment insurance	2.70
Workmen's compensation	2.32
Vacation and holiday pay included in regular 40-hour week	----

Calculation of labor expense percentage to apply

(1,600 hours @ 18.88%) 16,000 x 0.1888 = 302.08
(760 hours @ 6.52%) 760 x 0.0652 = 49.55
351.63 351.63/2,360 = 14.90% or 15%

Table X -- Depreciation (Account 340)
(Potato Dice Dehydration Plant)

Depreciation is not included as a cost because of the uncertainty of the write-off period that may be allowed. (See "Business Considerations" in Volume I.) The depreciation charges that would be incurred in this plant are calculated below for two possible write-off periods:

1. Assuming normal life expectancy and probable useful lives (as given in Bulletin F, U.S. Treasury Dept., Bureau of Internal Revenue)

Property Item	Original Cost 1/	Estimated 10% Salvage Value	Cost to be Depre-ciated	Useful Life (years)	Annual Depre-ciation Charge
Building and Grounds	$215,000	$21,500 2/	$193,500	50	$.3,870
Equipment	308,545	30,855	277,690	15	18,510
Total	$523,545	$52,355	$471,190	--	$22,380

Depreciation Charges

Per operating day ($22,380/200) $112

Per lb. of product at 6:1 ($112/33,340) $0.0034
Per lb. of product at 7:1 ($112/28,600) 0.0039
Per lb. of product at 9:1 ($112/22,220) 0.0050

2. Assuming 5-year write-off of 75% of capital investment

Total capital investment $523,545

75% to be written off $392,660

Annual charge ($392,660/5) $78,530

Depreciation Charges

Per operating day ($78,530/200) $393

Per lb. of product at 6:1 ($393/33,340) $0.0118
Per lb. of product at 7:1 ($393/28,600) 0.0137
Per lb. of product at 9:1 ($393/22,220) 0.0177

1/ Includes Engineering Construction Fees (Building and Grounds $5,000; Equipment $25,000)

2/ Includes value of land not depreciated

Table XI -- Taxes and Insurance (Account 350)
(Potato Dice Dehydration Plant)

Account No.			Cost per Operating Day
350 -- Taxes and Insurance Expense			$66
For purposes of this estimate, taxes and insurance on property are combined.			
Estimated cost of facilities		$525,000	
Taxes and insurance at 2 1/2%		$13,125	
Cost per operating day ($13,125/200)	$65.62		

Table XII -- Packing Supplies and Expenses (Account 370)
(Potato Dice Dehydration Plant)

Account No.	Cost per Operating Day
370 -- Total Packing Supplies and Expenses	$1,671
Cans	
Allowing 2.75 pounds of potato dice per No. 10 can	
28,600 pounds daily output/2.75 = 10,400 cans per day @ $99/M	$1,030
Cases	
1,735 per day (6 cans per case) @ $299.25/M	520
Supplies	
Straps, glue, recipe sheets, etc. @ 1¢/can	104
Allowance for losses (1% of $1,654)	17

Table XIII -- Inspection and Control (Account 380)
(Potato Dice Dehydration Plant)

Account No.			Annual Cost	Cost/Operating Day
380	-- Total Cost, Inspection and Control		$14,343	$72
	Salaried Employees:			
	Quality Control Technologist	$6,000		
	Add labor expense (6.52%)	391	$ 6,391	
	Hourly Employees:			
	3 laboratory technicians @ $1.00/hr. (4,800 hrs.)	$4,800		
	Labor expense (24%) (see Table V)	1,152	5,952	
	Supplies and Other Miscellaneous Expenses (estimated)		2,000	

Table XIV -- Miscellaneous Plant Expenses & Income (Account 390)

Account No.				Cost/Operating Day
390	-- Miscellaneous Plant Expenses			$191
391	- Lunch room operation - Assumed that sales of meals would offset the lunch room expense			---
392	- Chemicals			101
	Lye 1/ - 20 pounds per ton of potatoes = 2,000 lbs/day			
	1 ton lye @ $3.50 per cwt.	$70.00		
	Freight - Tacoma to Idaho	21.00	$91	
	Sulfite - 200 pounds sulfite @ $0.05		10	
393	- Sale of trimmings, fines, etc. Trimmings from preparation and rejects from final inspection might have some market as cattle feed. The "fines" from screening might have a market as soup stock.			---
	Cost of hauling away waste - 20 tons @ $2 a ton			40
394	- Other miscellaneous costs (estimated)			50

1/ Cost of lye given for solid lye. Liquid lye costs would be as follows:

1 ton lye @ $2.55 per cwt (dry basis)	$51.00	
Freight on 50% solution - or 2 tons liquid	42.00	$93.00

Table XV -- General and Administrative Expenses (Account 600)

Account No.	Cost/Operating Day
Estimated at 4% of a production cost (of 35¢/lb.)	$400

28,600 lbs. x 35¢ x 4% = $400

Annual cost ($400 x 200) $80,000

This estimate is consistent with World War II experience when dehydrators reported General and Administrative Expense ranging from 1% to 15% of total production cost, and averaging between 4% and 5%. This annual cost might be made up as follows:

610	- Salaries	General manager	$10,000			
		Office manager	6,000			
		Personnel Officer	4,800			
		Clerks (3 @ $3,000)	9,000	$29,800		
		Labor expense - 6.52%		1,940	$31,740	
620-690	- Other Expenses				48,260	$80,000

CHAPTER VI

SUMMARY OF CAPITAL AND CREDIT REQUIREMENTS
FOR A 100-TON PER DAY POTATO DICE DEHYDRATION PLANT

Fixed Capital and Credit Requirements:			
Plant Equipment		$284,000	
Buildings and Grounds		210,000	
Construction Engineering Fees		30,000	
6-Month General Expense: (From "Production Costs")			
From Table IV - Raw Material Procurement	$4,800		
From Table XIII - Inspection & Control	7,200		
From Table XV - General Administration	40,000	52,000	$576,000
Operating Capital and Credit Requirements:			
Estimated Advance Payments to Growers, Insurance, Utilities, etc.		$ 25,000	
75-day Operating Costs ($10,000/operating day) 1/		750,000	
25-day Inventory of Manufacturing Supplies (exclusive of raw commodity) ($1,700/operating day)		42,500	817,500
Sub-total			$1,393,500
General Contingency Fund:			
Equivalent to approximately 10% of Estimated Capital Requirements			139,500
ESTIMATED TOTAL CAPITAL AND CREDIT REQUIREMENTS			$1,533,000

1/ Based on 28,600 lbs. dehydrated potato half-dice per day at an approximate cost of 35¢/lb.

FIG. 1 USUAL PLANTING AND HARVESTING PERIODS AND AVAILABILITY FROM STORAGE FOR POTATOES IN PRINCIPAL PRODUCING STATES.

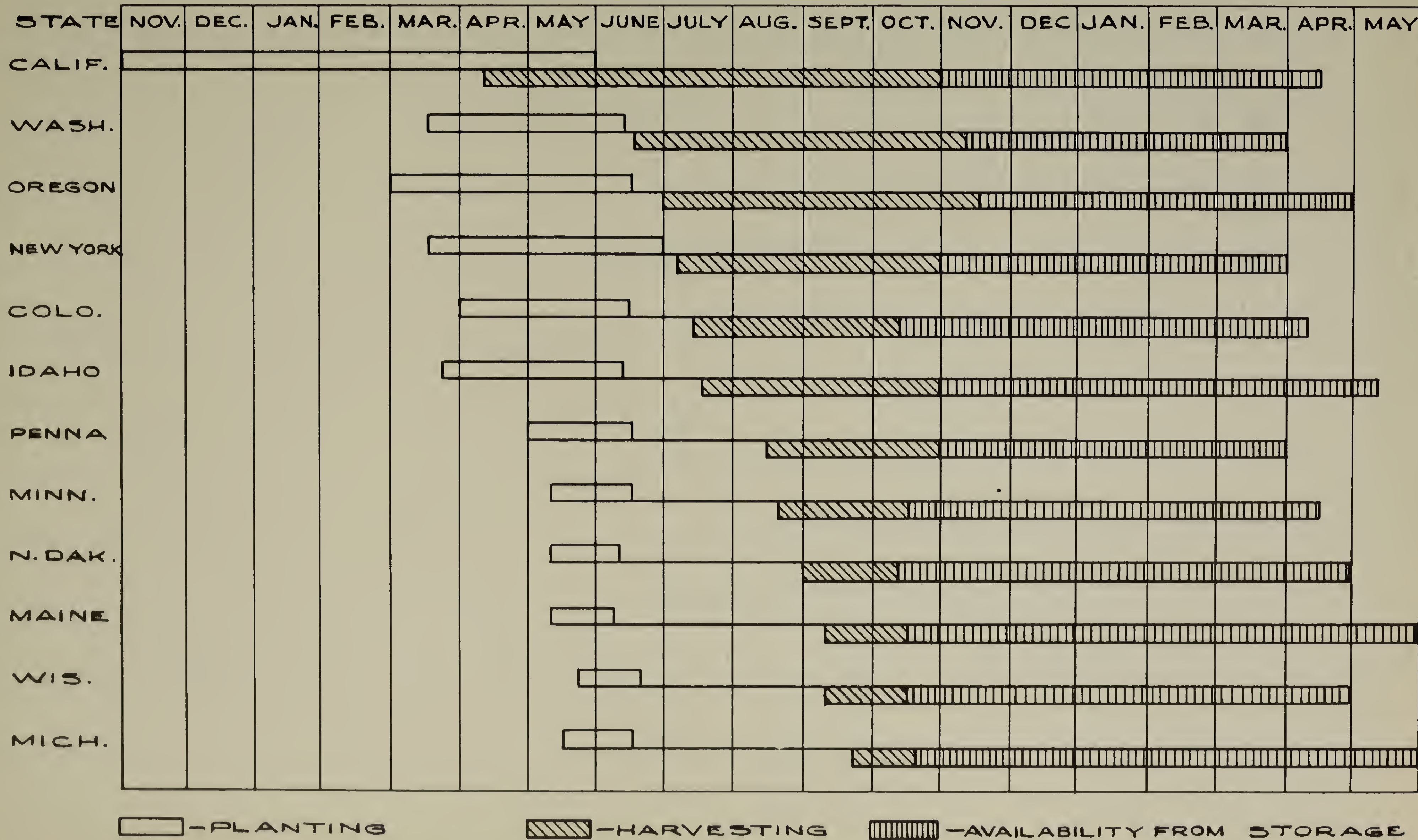
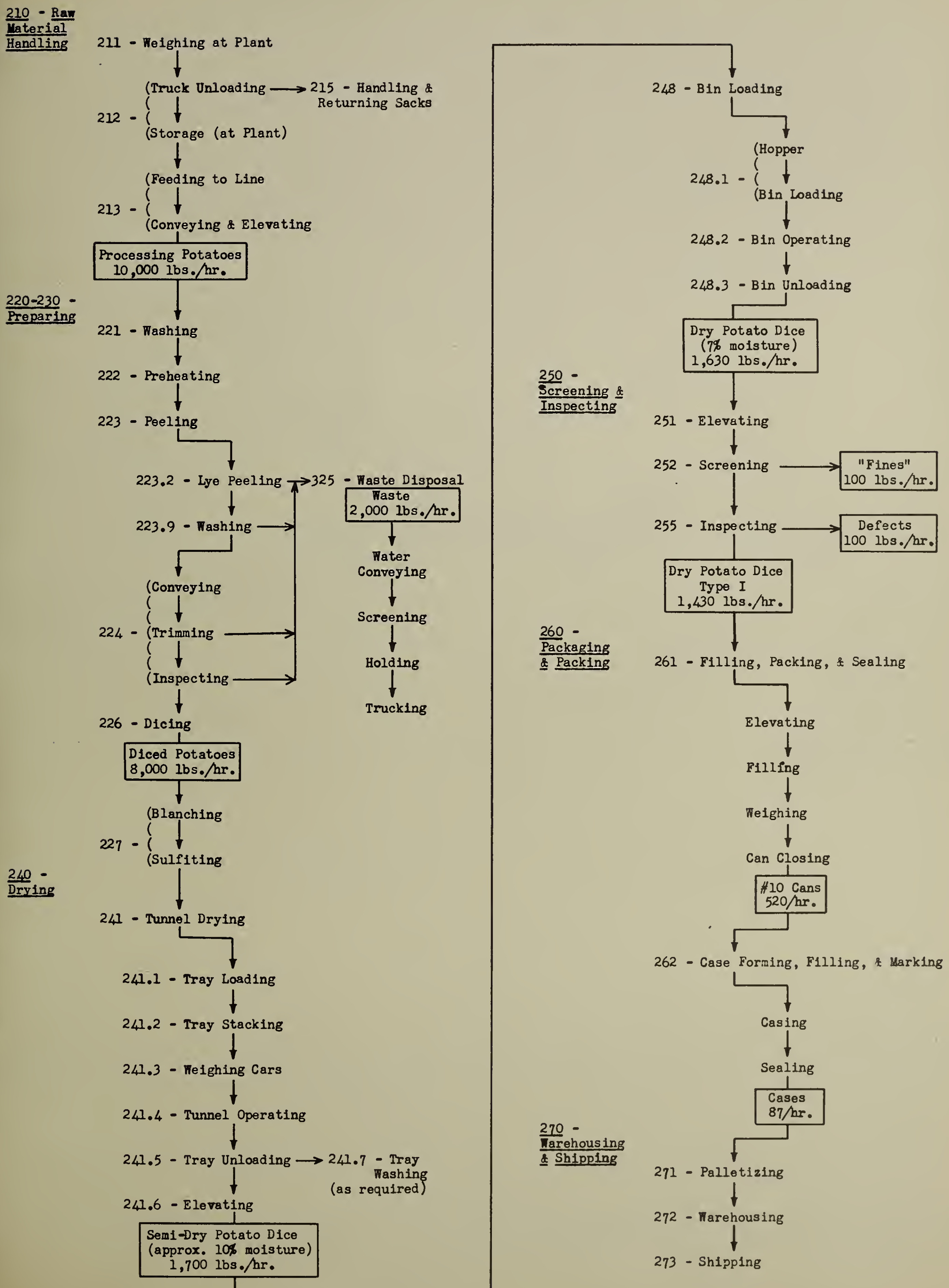


Figure 2 -- FLOW SHEET FOR WHITE POTATO DICE DEHYDRATION
(Capacity - 100 Raw Tons per Day)



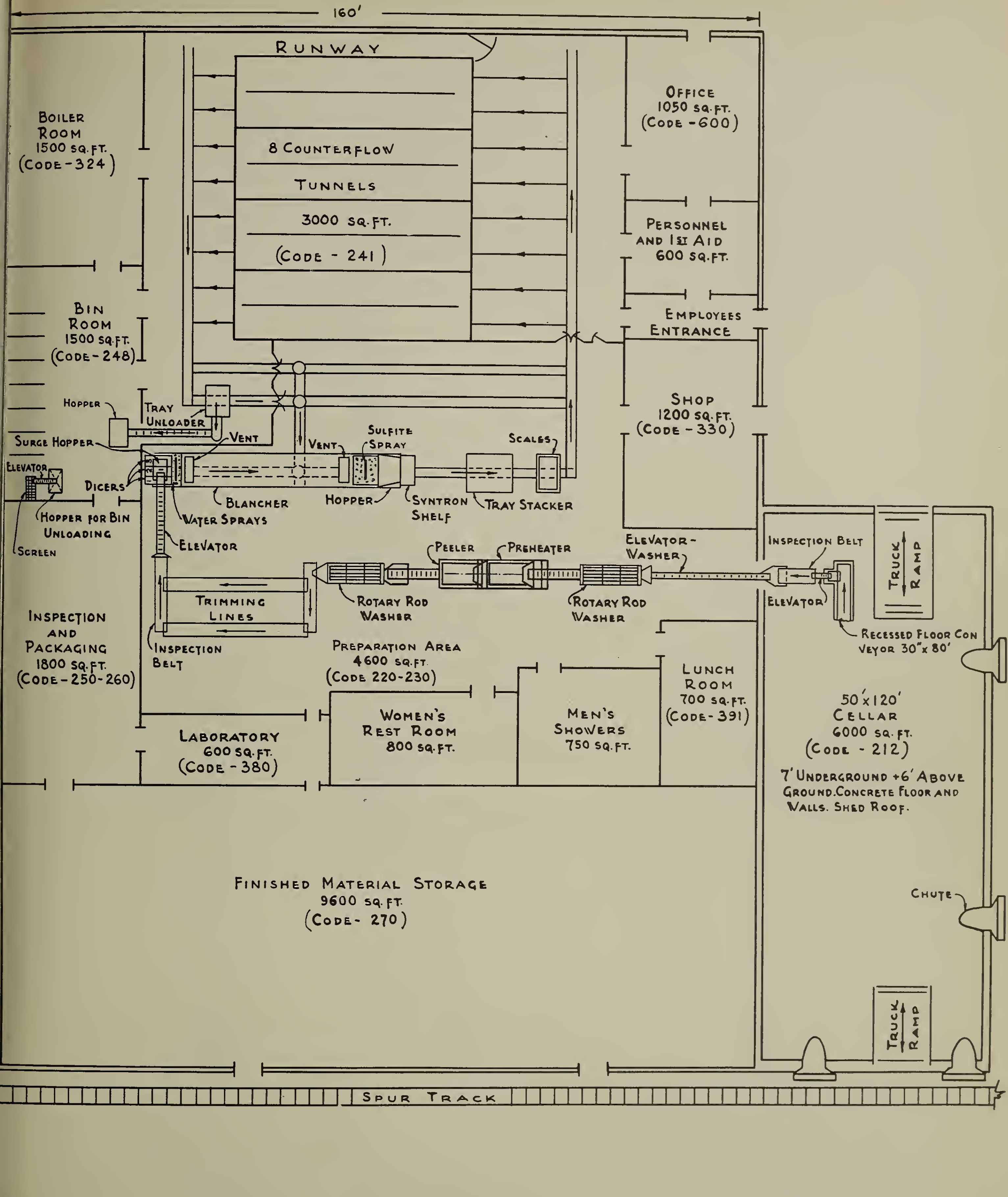


FIGURE No. 3

PROPOSED FLOOR PLAN FOR POTATO DICE DEHYDRATION PLANT

APPROXIMATE AREA 42,000 SQ. FT.

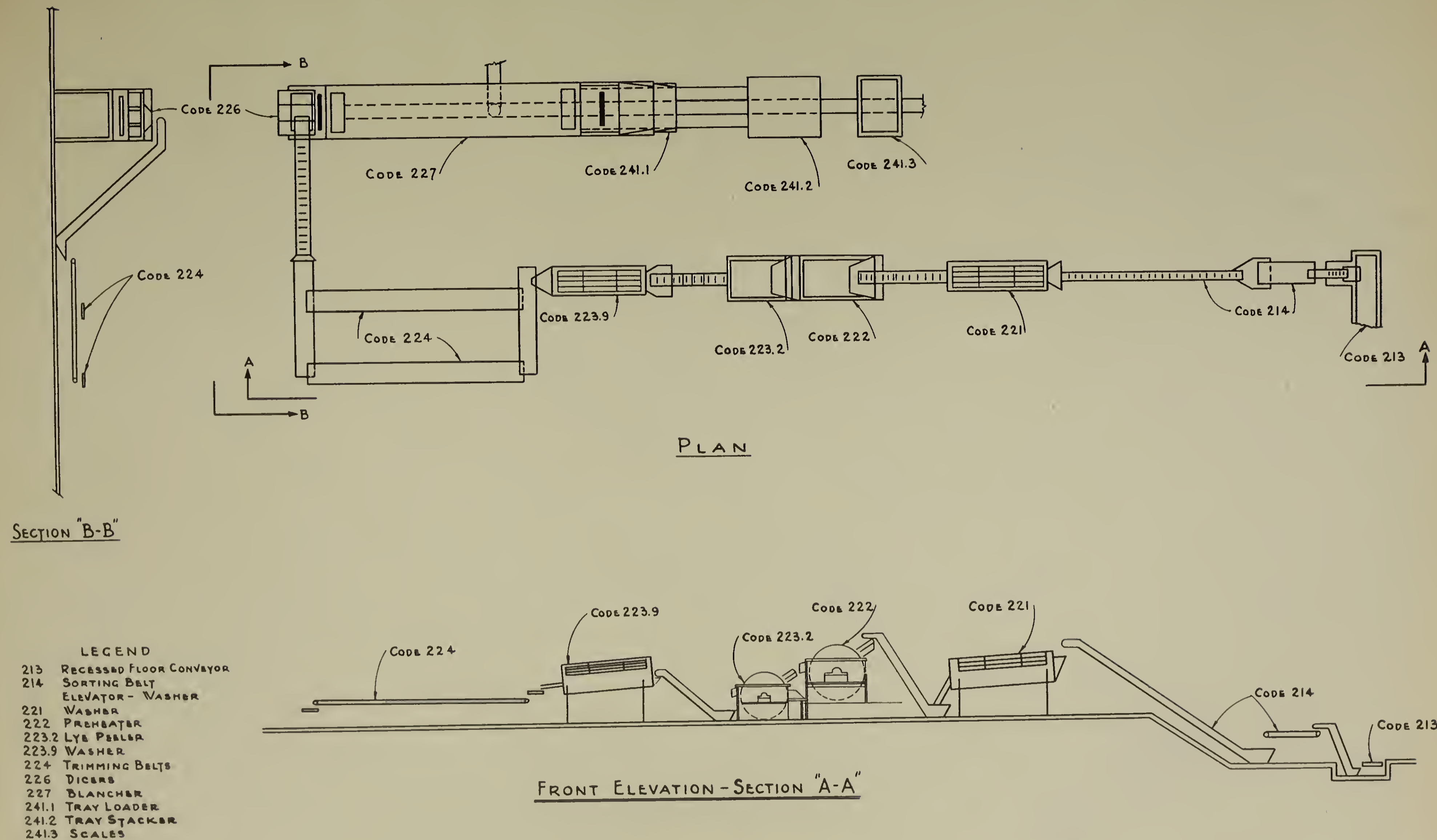
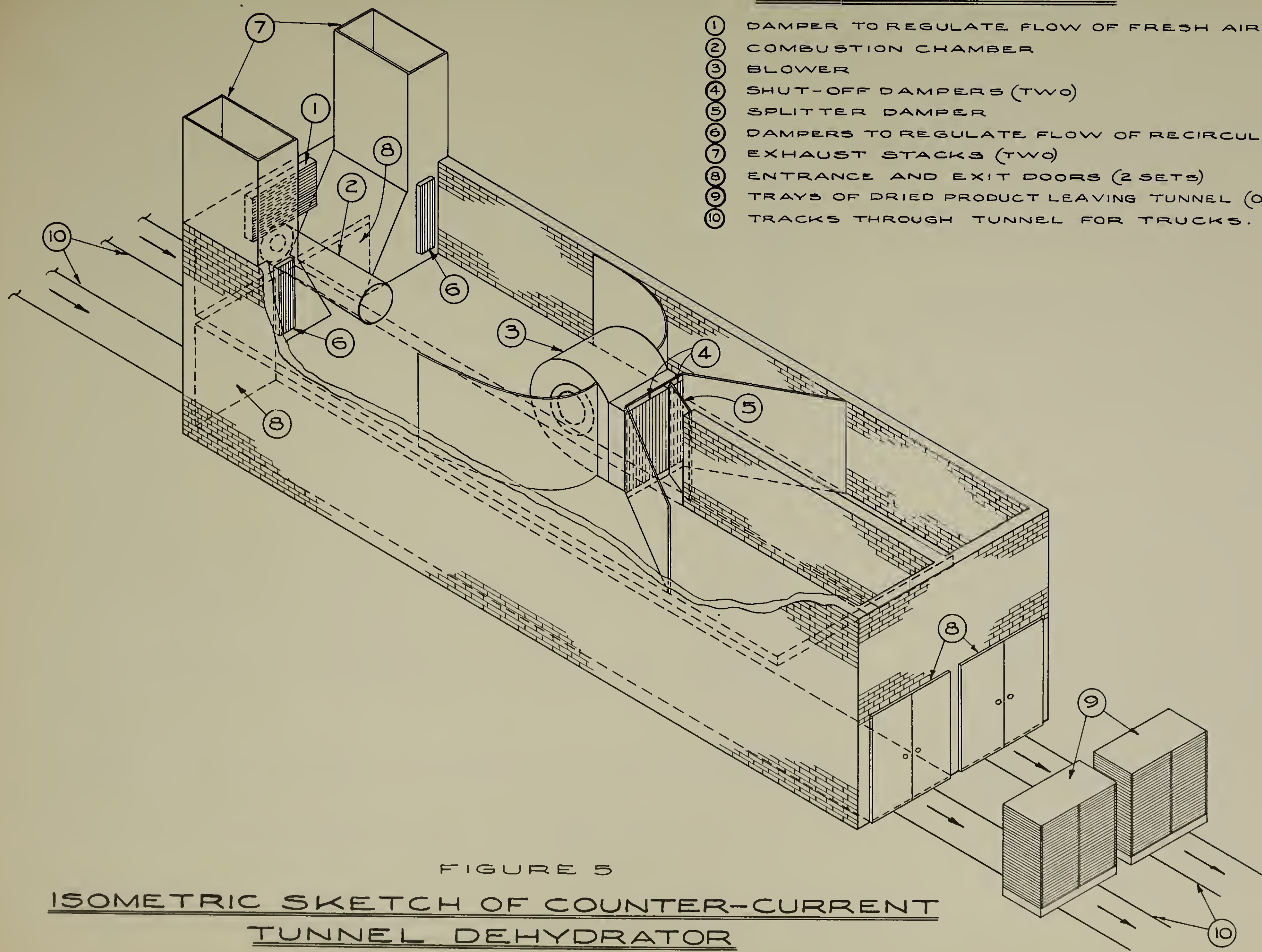


Figure No. 4

PREPARATION LINE FOR POTATO DICE DEHYDRATION PLANT



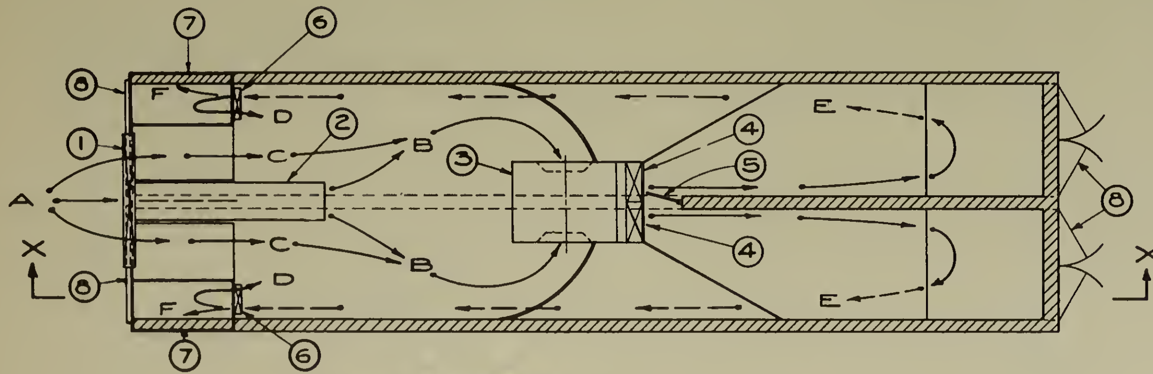
GENERAL NOTES.

1. DAMPER TO REGULATE FLOW OF FRESH AIR
2. COMBUSTION CHAMBER
3. BLOWER
4. SHUT-OFF DAMPERS (TWO)
5. SPLITTER DAMPER
6. DAMPERS TO REGULATE FLOW OF RECIRCULATING AIR (TWO)
7. EXHAUST STACKS (TWO)
8. ENTRANCE AND EXIT DOORS (2 SETS)
9. TRAYS OF DRIED PRODUCT LEAVING TUNNEL (ON TRUCKS)
10. TRACKS THROUGH TUNNEL FOR TRUCKS.

FIGURE 5

ISOMETRIC SKETCH OF COUNTER-CURRENT TUNNEL DEHYDRATOR

(CODE 241)



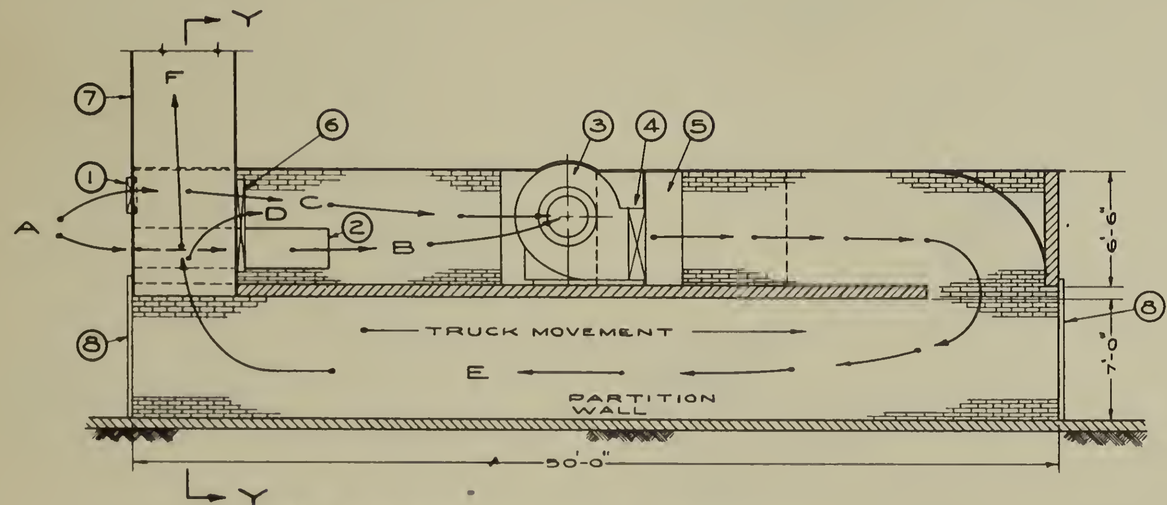
PLAN BELOW ROOF LINE

GENERAL NOTES

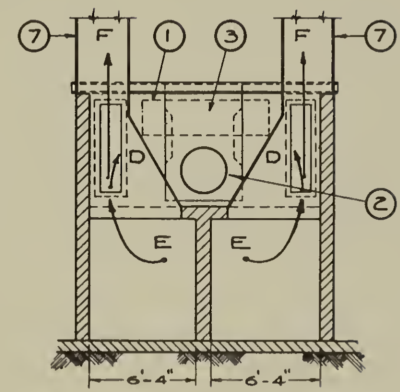
1. DAMPER TO REGULATE FLOW OF FRESH AIR
2. COMBUSTION CHAMBER—7,000,000 BTU/HR
3. BLOWER—ACCEPTABLE MODEL STURTEVANT SILENTVANE FAN, DESIGN 10, CLASS I, SIZE 105, DWDI, 30 H.P. MOTOR
4. SHUT-OFF DAMPERS (TWO)
5. SPLITTER DAMPER
6. DAMPERS TO REGULATE FLOW OF RECIRCULATING AIR (TWO)
7. EXAUST STACKS (TWO)
8. ENTRANCE AND EXIT DOORS (2 SETS)

AIR FLOW NOTES

A—FRESH MAKE-UP AIR
B—HOT MAKE-UP AIR FROM COMBUSTION CHAMBER
C—FRESH MAKE-UP AIR BY-PASSING COMBUSTION CHAMBER
D—RECIRCULATED AIR FROM TUNNEL EXHAUST
E—CONTROLLED TEMPERATURE DRYING AIR
F—EXHAUST AIR FROM TUNNEL TO OUTSIDE



SIDE ELEVATION—SECTION "XX"



SECTION "YY"

FIGURE 6

COUNTER-CURRENT TUNNEL DEHYDRATOR FOR POTATOES OR CARROTS (DICED)

(CODE 241)

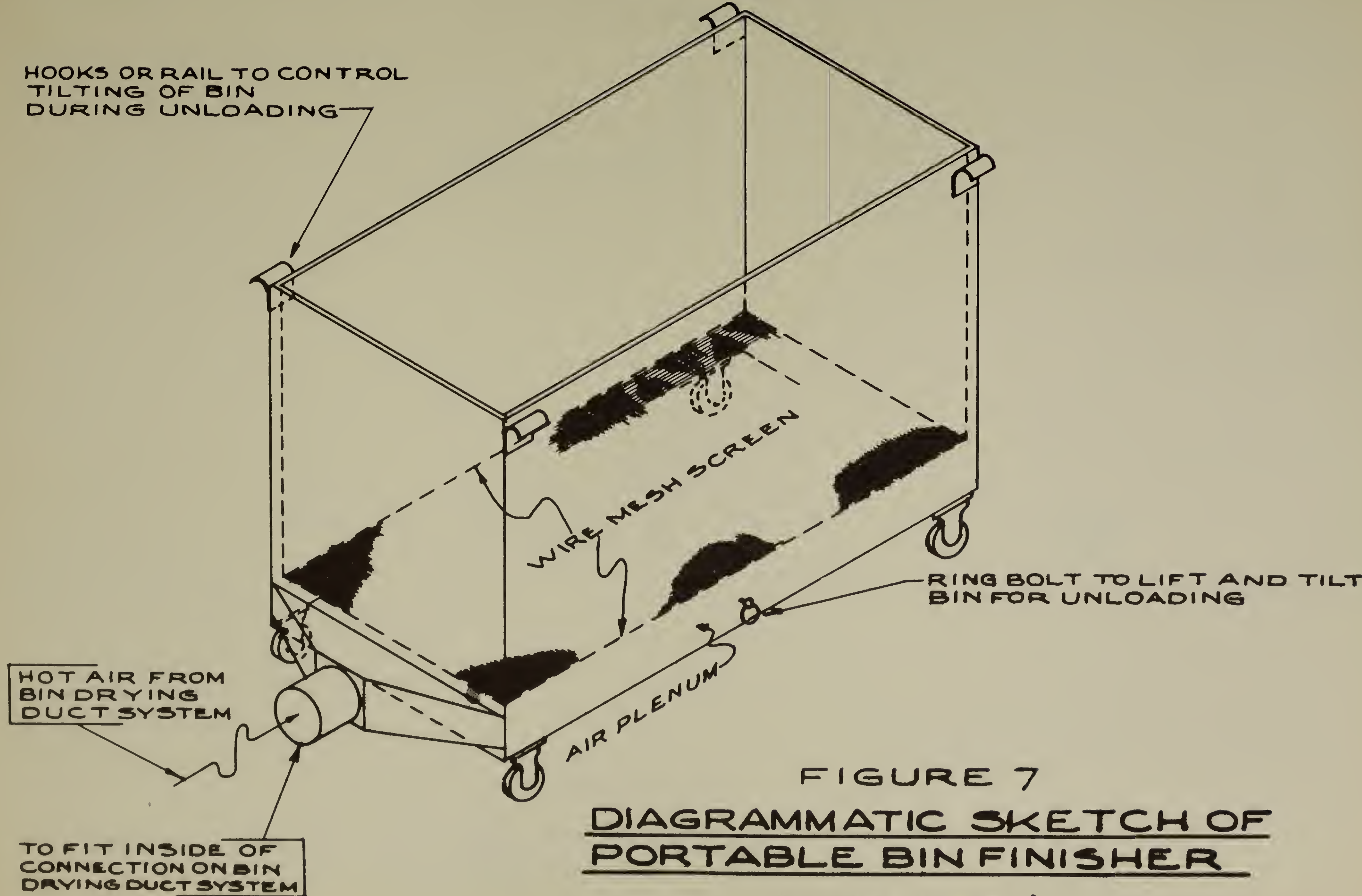


FIGURE 7

DIAGRAMMATIC SKETCH OF
PORTABLE BIN FINISHER

(CODE 246.1)

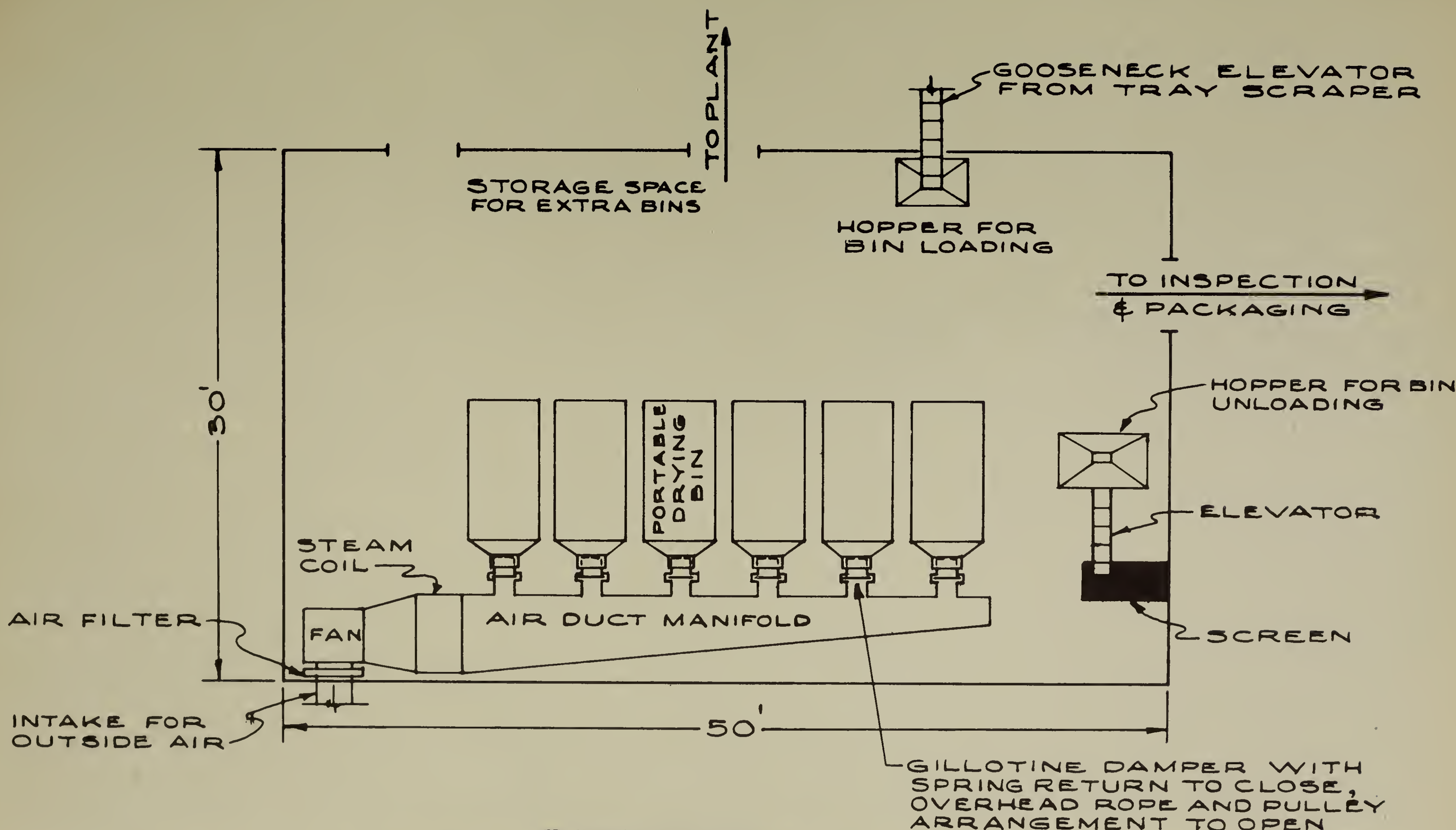


FIGURE 8

LAYOUT OF BIN FINISHING ROOM
FOR POTATO & CARROT DICE

CODE 248

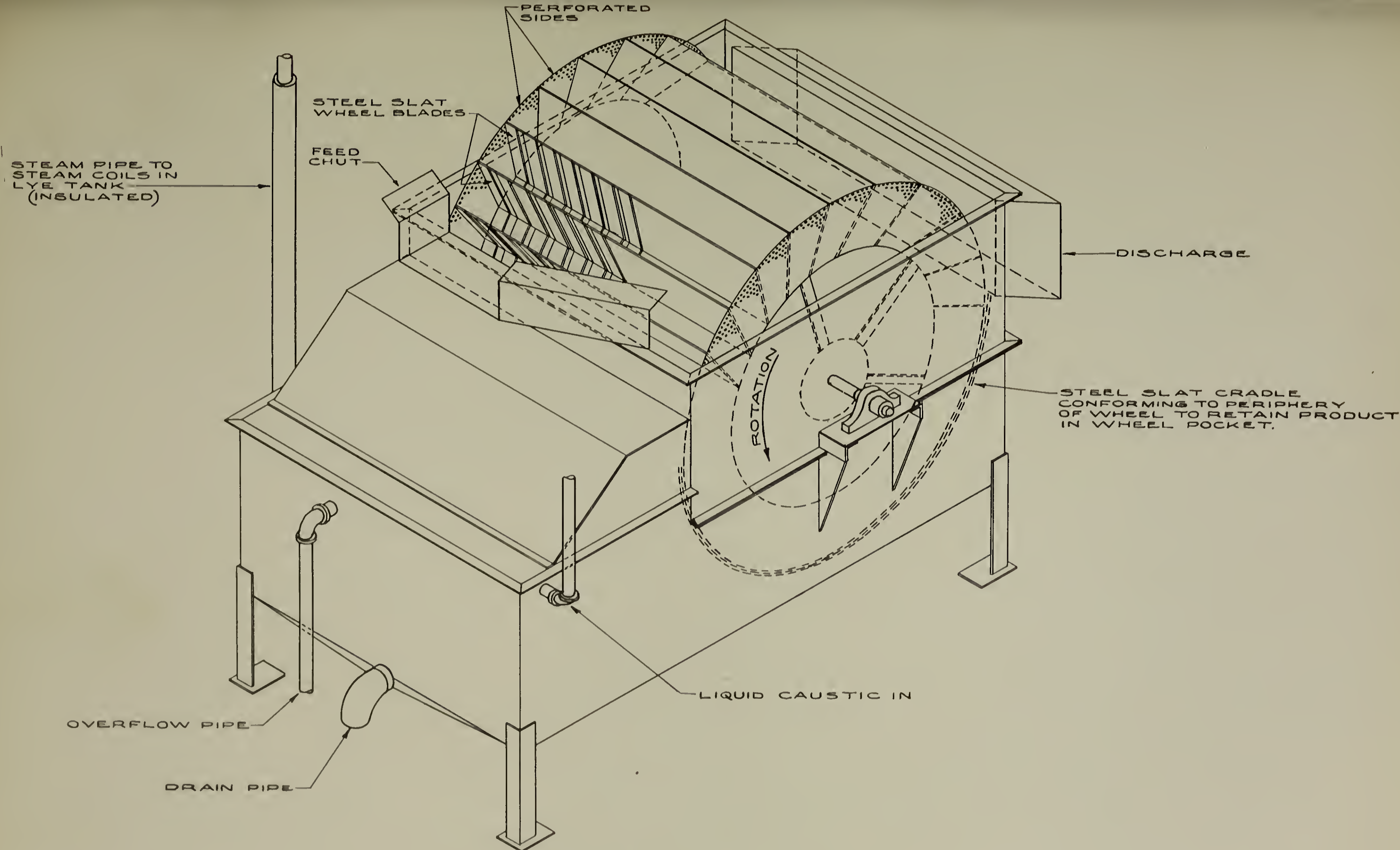


FIGURE 9

ISOMETRIC SKETCH OF ROTARY LYE PEELER.

(CODE 223.2)

PAGE NO. 49

Part Two

POTATO GRANULE DEHYDRATION PLANT

(Type IV, Class 1)

CHAPTER I

BASIC ASSUMPTIONS

Foreword

Production in the United States of a potato granule product that is acceptable under current Military Specifications has been accomplished only since World War II. A similar product was produced in England during the War. Thus far, only five plants in the United States have delivered significant quantities of this product to procurement agencies of the Armed Forces, and most of these deliveries were made in the past two years. In all five plants, production operations are based on an "add-back" process involving the return of dried potato granules to the freshly mashed potatoes to promote granulation. Although the same basic process is used in these plants, methods and facilities differ markedly from plant to plant. Moreover, a continuing succession of changes in methods and means of operation is being made in individual plants, with the object of reducing costs and obtaining a satisfactory product with the desired bulk density.

The differences between plants and the continuing changes indicate that the industry is in an early stage of development and that there is considerable uncertainty as to a proper course of action. This state of flux will continue to exist until further fundamental information concerning the processes is made available, and the most desirable processing methods are standardized. Information being developed in investigations now under way, coupled with knowledge that is being gained through increased experience in continued commercial production, should lead to major improvements in plant procedures in the very near future. It appears certain that much of the equipment used in future plants will differ greatly from that in existing commercial installations. As confidence is gained through increased knowledge of processing requirements, means will be found to mechanize various operations that are now performed manually, so that present high labor costs will be reduced. Through experimentation, undesirable types of equipment that tend to damage the product will be eliminated and improved designs for various essential devices will be developed. With proper processing techniques and equipment an excellent dehydrated product that conforms to current Military Specifications can be produced. The fact that the product has application to civilian as well as military needs is expected to contribute greatly toward rapid advancement of the industry.

Detailed information concerning existing commercial installations has not been made public, and is regarded by plant owners as valuable business property. The following descriptions, therefore, cover only non-secret information volunteered by plant management and equipment manufacturers, disclosures made in patents and technical publications, and some of the information developed in the course of investigations in research laboratories. Details of plant layout and costs for a recommended process can not be given on the basis of present information. The processes now in general use are outlined and certain information on operating procedures given in this Supplement. Also, data are given on yields and material balances. It must be emphasized, however, that these data were derived in small-scale pilot plant operations, and that actual values in commercial plant operation may differ considerably. Certain facilities now used in industry probably will not be installed in any future plant, and, therefore, items of this type are not fully described. Instead, a partial list of required equipment is given and suggestions made regarding the facilities considered likely to be used in future plants.

Various patents which relate to the production of potato granules have been issued. A list of some of the important patents, together with other references of special interest, has been published elsewhere. 1/ The prospective dehydrators should obtain legal counsel to determine their rights and obligations in relation to existing patents.

The planning of a dehydration plant meeting national emergency needs should take full cognizance of the information and suggestions given in Volume I of this Handbook.

Product Desired

The information in this Supplement pertains to the process and plant facilities required to produce dehydrated potato granules (Type IV, Class I) in accordance with the Military Specification "Potatoes, White, Dehydrated" (MIL-P-1073A) dated 12 December 1950. "Type IV, Class I" is the designation used to identify a granular, dehydrated product that is prepared from precooked mashed potato. In this Supplement this product generally will be referred to as "potato granules".

Bases for Operations and Facilities

A. Location of Plant

Most of the potato dehydration during World War II was done in Maine and Idaho, because these areas were the major producers of varieties best suited for dehydration use. These areas are still considered the best sources of suitable potatoes for dehydration. Three of the five present potato granule plants are located in Idaho. The Snake River Valley of Idaho is probably one of the most favorable areas for the location of a potato granule plant. This area has a large production of a potato variety (Russet Burbank) that is high in solids content and generally suitable for making granules.

B. Operating Basis

It is assumed that the plant will operate 18 hours per day, six days per week, for approximately nine months per year. For normal operation there will be two 10-hour shifts per day, with each shift having a 30-minute lunch period and two 15-minute "break" periods. It is assumed that major clean-up operations will be handled by a special crew which will work each day during the time the plant is not in operation.

C. Raw Commodity Used

It is assumed that the plant will use the Russet Burbank variety of potatoes, and that the potatoes will be suitably conditioned for dehydration when received.

1/ Olson, R. L., and Harrington, W. O. Dehydrated Mashed Potatoes — a Review. Albany, Calif. 1951 (Bureau of Agricultural and Industrial Chemistry, Circular AIC-297) 23 p.

D. Plant Capacity and Yields

The plant has been designed to have a normal processing capacity of 50 tons per day of raw potatoes when operating 18 hours per day.

The over-all shrinkage ratio of the plant is assumed to be approximately 5.2 : 1). This value was obtained in a typical run in a small scale pilot plant operation in which U. S. No. 1 grade Russet Burbank potatoes, containing 23% total solids, were used as raw material. In commercial plants the shrinkage will generally be greater, due principally to the practice of often using imperfect potatoes (of good quality) which result in relatively high trimming and peeling losses. It is probable that over-all shrinkage ratios in potato granule plants are generally lower than in diced potato dehydration plants (see Chapter I of Part One for shrinkage ratios in potato dice plants). On the basis of a 5.2 : 1 shrinkage ratio, 100 pounds of raw potatoes yield about 19.3 pounds of Type IV, Class I, potato granules. In addition, approximately 1.4 pounds of coarse granules, suitable for stockfeed, will be produced.

E. Storage Space

Storage space in the plant building should be provided for handling a raw potato supply equivalent to at least seven days of plant operation. In addition, space should be provided for holding approximately a 30-day production of packaged and cased potato granules plus a 10-day supply of empty cans and cases, or any desired combination of these items. In cold climates heaters should be provided so that the storage space for raw potatoes may always be maintained at a temperature near 60° F.

If the dehydrator decides to accept potatoes that contain more than 3% reducing sugars, special air circulation and heating facilities must be installed in the plant storage to allow conditioning of the potatoes to reduce sugar content. 1/

F. Waste Disposal

It is assumed that the potato trimmings, about nine tons per day, will be hauled away for use as stockfeed.

1/ Abstract of a joint report by the Quartermaster General's Office, U. S. Army, and the University of Maine, A. Frank Rose, et al. Selecting and Storing Potatoes to Avoid Darkening. Food Industries 18 (7): 77-79, 210-216. July 1946.

CHAPTER II

SUPPLY OF RAW POTATOES

The problems and methods involved in procuring a suitable supply of white potatoes for the potato granule plant are essentially the same as for a potato dice plant. Consequently, full heed should be taken of all information given in Chapter II, Part One, of this Supplement. In addition, one special requirement must be met for potato granules. This requirement is that the potatoes, when cooked, must crumble readily and be reducible to a dry floury mash. Potatoes that produce a soggy, sticky, or rubbery mash should not be used. Potatoes that produce only a fair mash are also undesirable because this type of material tends to be damaged easily during processing and the final product is usually of poor quality.

It is generally recognized that mashing quality is directly related to solids content. Potatoes of low solids content are not suitable for use in the production of potato granules. Because of its relationship to dry solids content, and the relative ease and rapidity with which it may be determined, specific gravity is often used as a criterion of potato quality. 1/ Potatoes of suitable varieties that have a specific gravity of 1.080 or higher generally produce a mash of good quality. The specific gravity method, however, does not reflect possible wide variations in solids contents within a given potato. Potato granule plant operators state that the test they find most dependable is to cook and mash representative samples of the potatoes in the same equipment and under the same conditions as used in the actual processing operations.

Some plants are equipped to produce both potato granules and dehydrated potato dice. This has a definite advantage in that the potatoes that tend to produce a mediocre mash often can be used satisfactorily to produce potato dice, and the potatoes of best mashing quality can be reserved for use in the production of potato granules.

1/ Rose, H. D., and Cook, H. T., Handling, Storage, Transportation, and Utilization of Potatoes. Washington, D. C. 1949. (U. S. Dept. of Agriculture Bibliographical Bulletin 11) 163 p.

CHAPTER III

PLANT PROCEDURES AND FACILITIES

This chapter gives information on the procedures and certain of the facilities required for a potato granule plant. For reasons given previously, the information is necessarily incomplete and of restricted value in the planning of a future plant. The information is classified and presented in accordance with the classification key given in Appendix D ("Operation Classification Code") of Volume I. The accompanying flow-sheet, equipment list, and other illustrative material have been labeled in accordance with this same classification. This procedure has been followed so as to provide a cross-reference system for identifying or discussing any phase of the operations.

It is assumed that the plant will use the "add-back" process. As has been previously mentioned, only the "add-back" process has proved successful in the production of a potato granule product that is acceptable under current Military Specifications. A distinguishing feature of this process is that previously dried potato granules, called "seed granules" or "seed", are added to and mixed with the fresh potato mash in the course of processing. Obviously, the name of the process is derived from the act of adding back seed granules to the mash. When the mash and seed granules are used in correct proportions, a friable mixture is obtained which can be satisfactorily processed.

100 — RAW MATERIALS

The problems and methods of procuring a suitable supply of potatoes for the plant have been discussed under "Supply of Raw Potatoes".

200 — MANUFACTURING OPERATIONS

<u>210</u> -- <u>Raw Material Handling</u>

<u>211</u> — <u>Weighing (at plant)</u>
<u>212</u> — <u>Unloading (at plant)</u>
<u>213</u> — <u>Feeding to line</u>

It is assumed that the raw material will be handled in approximately the same manner as outlined for the potato dice plant under Code 210, Chapter III, Part One of this Supplement.

<u>220-230</u> — <u>Preparing</u>

<u>221</u> — <u>Washing</u>

A rod-type rotary washer is commonly used, where the potatoes are tumbled while exposed to sprays of water.

222 — Preheating

In the preheater, potatoes are heated in water at 140° F. to 160° F. for a period of from four to seven minutes, as required. A rotary-type preheater is suggested in this operation. A machine similar to the lye peeler illustrated in Figure 9 may be used; the steam coil section is omitted and provision is made for direct steam injection when the machine is to be used as a preheater. Draper-type preheaters also have been used with success in industry, but require more floor space than the rotary type.

223 — Peeling

223.2 — Lye peeling

Peeling losses are assumed to be 12% in this operation but may vary from below 8% to over 25% depending on the variety, age, and condition of the tubers at the time of processing, as well as the peeling method employed.

Both lye and steam peeling methods are used successfully on potatoes. 1/ For the proposed plant, lye peeling is suggested. A rotary-type lye peeler, equipped with steam heating coils, of the type shown in Figure 9, will be adequate. This peeler must be designed for a run-through capacity of at least three tons per hour. Operating conditions for lye peeling of potatoes must be determined by test, but in general, complete submersion of the tubers for a period of two to three minutes in a 14% to 15% caustic soda solution held at a temperature of from 200° F. to 205° F. will be found satisfactory.

Draper-type lye peelers have also been used successfully for potatoes but require more floor space than the rotary type.

223.9 — Washing (to remove peel)

This washing operation is the finishing step for the peeling operation. Loosened skins and entrained lye are washed off while the potatoes are tumbled and exposed to water sprays.

226 — Cutting

The potatoes are cut lengthwise into 5/8" slices. Two cutting machines, each with a capacity of approximately three tons per hour, will be needed. One of the machines is held in reserve in case the other breaks down. A supply of spare parts should be provided so as to assure continuous operation. Cutting is done before trimming so that the interior of the potato will be exposed and defective material can be removed.

224 — Trimming

In this operation defective material is removed by women stationed on two sides of a belt conveyor. The sound slices of potato are conveyed directly to the washing operation.

1/ In one plant that produces potato granules for the civilian market, the potatoes are given a rough abrasion peel. The considerable amount of skin that is left on the potato is removed in a screening operation after the granuled product is dried.

Trimming losses have been estimated to be 5% of the original raw material, but may vary from 2% to 20% or higher, depending on the condition of the raw stock, peeling efficiency, discoloration, etc.

225 — Washing

After the trimming operation the slices are washed so as to remove trim fragments and surface starch. In a plant where the cooker is installed at a higher level than the trimming conveyor, the washing operation may be conveniently done by water-sprays on the elevating conveyor which is used to transport the slices to the cooker.

227 — Cooking and cooling

The slices must be thoroughly cooked but not overcooked. An adequate cook reduces the potato to a condition such that it forms a mealy product when mashed. Undercooking tends to result in small lumps or "rice grains" in the mashed product, whereas overcooking tends toward the production of a sticky product.

Cooking in steam at atmospheric pressure is generally recommended. In most plants the cooking operation is done in a unit similar to a continuous atmospheric steam blancher. The cooker differs from a conventional belt blancher mainly in that provisions are made to move the conveyor belt at a relatively slow speed and to carry a heavier load of material on the belt.

For 5/8-inch potato slices the depth of material on the cooker belt is usually held constant at between six and eight inches. Since the apparent density of the randomly piled slices is approximately 35 lbs./cu. ft., the belt loading is about 17 lbs./sq. ft. for slices piled six inches deep and about 23 lbs./ sq. ft. for an eight-inch depth.

For a plant operating near sea level the cooking time required for 5/8-inch slices piled six inches deep usually will be between 30 and 35 minutes. However, it is not possible to state accurately the cooking time required since the time is dependent upon a number of factors. Among the factors that may influence cooking time are the following:

1) Characteristics of the raw material, such as variety and maturity

2) Adequacy of steam distribution within the cooker

3) Depth to which the potato is loaded on the cooker belt. Obviously, the greater the depth of load the longer will be the time required for penetration of heat to the center

4) Altitude of the plant site. The greater the altitude the lower will be the temperature that can be maintained, and consequently the longer will be the cooking time.

The cooker should be designed to insure uniform distribution of steam and the steam supply must be adequate to maintain a constant temperature within the cooker. The steam must be introduced into the cooker in such a manner that the potato slices are not exposed to jets of steam which may cause mechanical damage to the potatoes and result in a sticky product.

Provisions should be made for uniform loading and spreading of the potato slices. The drive for the cooker belt should provide for a range of belt speed variation such that the cooking time may be varied between 25 and 45 minutes.

Cooling of the cooked slices prior to mashing is believed to be essential when the slices are to be mashed in a double drum masher (see Code 228). In pilot plant tests it has been found that some cooling before mashing facilitates feeding of the mashing drums and tends to minimize cell damage during passage of the material between the drums. The amount of cooling required is that which causes the starch on the surface of the cooked slices to undergo partial gelation. To effect gelation, the temperature of the surface of the slices must be brought to near 130° F. The required amount of cooling can be conveniently achieved by allowing the cooked slices to "steam off" (cool by natural convection) for approximately one minute as they are conveyed on a wire-mesh belt to the masher. To ensure rapid and uniform cooling, the depth of slices on the cooling-conveyor belt should not exceed three inches.

228 — Mashing

Double drum mashers of the type shown in Figure 11 are being used successfully in mashing pre-cooked slices, after the slices are partially cooled as described above.

Satisfactory results are obtained when the clearance between drums is held at 0.050-inch provided the potato has good mashing characteristics. If the potato has inferior mashing characteristics a moderate decrease in drum clearance tends to improve the mash in that it effects a reduction in lumpiness but does not increase stickiness significantly. Since the output of the masher is directly related to drum clearance, it is usually desirable to operate with the largest clearance that is consistent with formation of a satisfactory mashed product.

For the proposed plant one double drum masher with the features indicated in Figure 11 and Table I will be needed.

229 — Mixing, granulating, and sulfiting

Mixing, granulating, and sulfiting steps are handled as batch operations in existing plants. However, it is believed that continuous methods of operation will be adopted in future plants so as to obtain more efficient use of labor and equipment. Consequently, suggestions will be given concerning the procedures and facilities considered likely to be used in processing on a continuous basis.

Mixing

In this operation the mash and "seed" 2/ are mixed together for a short time preparatory to granulating. 3/ The mash and "seed" are mixed in such proportions that the moisture content of the mixture lies

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2/ The "seed" is the dried material, or granules, which is added to the freshly mashed potatoes to obtain a friable mixture that can be readily dehydrated (see introduction to this chapter).

3/ In some of the commercial plants the mixing, granulating, and sulfiting steps are simultaneously performed in a batch mixer.

MIXING OPERATION—POTATO GRANULE LINE
(Courtesy of J. R. Simplot Co.)

between 35% and 40%. When the moisture content of the mixture exceeds 40% difficulties are encountered in subsequent processing operations, and the package density of the dried product tends to be undesirably low. Moisture contents below 35% are undesirable in that they are attained by using excessive amounts of "seed", resulting in decreased plant capacity. Obviously, plant capacity is decreased as the recirculating load is increased. When a pneumatic conveying drier is to be used the moisture content of the mixture is normally between 37% and 39%. When a tray-type drier is to be used, the moisture content of the mixture is purposely held near 30% so as to prevent the granules from sticking together during drying.

In existing plants various kinds of batch mixers are used to mix the mash and "seed". Spiral-ribbon-and-paddle mixers, of steel and black-iron construction, are the types most commonly used. One plant is equipped with nickel-plated bowl mixers. Hand labor is generally used at present in charging the mixers and in handling the discharged product.

If a continuous double-ribbon mixer is used, the mash and "seed" may be continuously charged at one end of the mixer, mixed for a period of five minutes as the charge is conveyed to the opposite end of the mixer body, and continuously discharged through an adjustable end gate. The continuous mixer required for the proposed plant will be approximately 36" wide by 42" deep by 6' long. The tip speed of the outer ribbon should be approximately 100 ft./min. Manufacturers of mixing equipment should be consulted regarding the design of the ribbons used in the mixer, since the proper mixing and conveying action can be obtained only with ribbons of suitable pitch and dimensions. Further details concerning this equipment are given in Table I.

In existing plants mash and "seed" are measured volumetrically and charged by hand to the mixers. It is suggested that two automatic weighing devices be used in the proposed plant, one to weigh the mash and one to weigh the "seed". A conveyor should be installed to convey mash from the drum masher to the mash weigher. The two weighers should be designed and automatically controlled in such a manner that the mash-to-seed ratio may be held practically constant regardless of changes in the mash feed rate. Provisions should be made so that the mash-to-seed ratio may be adjusted by the operator. Further details concerning the weighing equipment are given in Table I.

Granulating

In the granulating step the mash and "seed" granules are intermixed, moisture is interchanged between wet and dry portions of the mass, and the potato cells are separated by gentle mechanical action. A suitable granulator should effect cell separation without fracturing cells to the extent that the potato granules are sticky when reconstituted. Granulation should be carried to the point where the product is mainly made up of single cells and very small aggregates of cells. If large clusters of cells predominate after granulating, there will be a rapid accumulation of excessively coarse material in the processing system.

Batch mixers used in the granulating operation in existing plants are of the same type as used in the preliminary mixing operation. It is suggested that a continuous granulator of the type shown in Figure 12, be used in the proposed plant. A small unit of this type has performed

very satisfactorily in small-scale pilot plant operations. 4/ It will be observed that this device provides for movement of air (at room temperature) over the moist granules during granulation. The circulating air promotes evaporation of moisture and cools the potato mass materially. Both of the latter effects are beneficial in that they reduce the holding time in a subsequent conditioning operation. Also, evaporation of moisture during granulation results in a reduction in evaporation load when the granules are dried.

In the granulator used in pilot plant operations, the tip speed of the agitator paddles is held at 50 ft./min. The product from the mixer is continuously fed at one end of the granulator, is subjected to the action of the paddles for a period of 20 minutes, and continuously discharged at the opposite end of the unit.

The continuous granulator for the proposed plant is approximately 36" wide, 42" deep, and 20' long. Additional details concerning this equipment are given in Table I.

Sulfiting

Military Specifications require that potato granules shall be sulfited and that the sulfite content (calculated as sulfur dioxide) shall not exceed 300 parts per million. Up to the present, specifications have not stipulated a minimum sulfite content. Application of sulfite to some potatoes is known to result in better color as the product comes from the drier and also better retention of quality when the product is stored under unfavorable conditions. The operator must determine experimentally the optimum sulfite level for his particular operation.

At present, insufficient experimental data are available to justify formulation of definite recommendations regarding the best procedure to follow in sulfiting potato granules. In the present industry, the sulfite is usually added in the mash-seed mixer, using a concentrated sulfite solution so as to avoid addition of large amounts of water. The solution should contain approximately 25% total solids composed of equal weights of sodium sulfite and sodium bisulfite.

The sulfiting should be done with spray nozzles operating under sufficient pressure to give a good distribution of the sulfite solution. A pump should be provided to deliver the solution to the spray nozzles at suitable pressure. The sulfite solution is conveniently supplied to the sprays from two tanks of such size that each will hold enough for one ten-hour shift. The second tank is used in making up fresh solution to desired strength while the first is in use.

Each sulfite make-up tank should be equipped with a mixer that will give vigorous stirring without beating air into the solution. Reasonable caution should be exercised in handling sulfite solutions to avoid contamination with metals such as iron and copper, since these speed the deterioration of the solution. It is suggested that steel tanks having interiors thoroughly coated with a suitable synthetic coating material be used for holding the sulfite solution. Hard waters should be avoided in making the sulfite solution since they cause precipitation of insoluble calcium sulfite, which not only results in a milky appearance of the solution, but upon accumulation may cause clogging of spray jets.

4/ A similar unit, designed for batch operation, is being successfully used at one commercial plant.

230 — Granule conditioning

The granule conditioning operation 5/ consists in holding the moist granules for a period of time, with the object of bringing about certain beneficial changes. These changes are believed attributable to retrogradation of starch and to an exchange of moisture between wet and dry particles of the mixture. The changes that occur cause further separation of cell aggregates during the subsequent fluffing operation and tend to eliminate stickiness in the mash when the dried product is prepared for table use. Results of experimental work indicate that the holding time required for adequate conditioning becomes smaller when the mixture is held at lower temperatures or at lower moisture levels. For the procedure outlined herein the holding time should be approximately 70 minutes.

The current industrial practice is to treat granule conditioning as a batch operation. In two plants the conditioning operation is performed by loading the moist granules into 50-gallon drums, storing the filled drums for the required period, and then discharging the drums — using hand labor throughout the operation. In another plant the operation is similarly performed, using portable bowls of large size instead of drums. These procedures result in a fairly low equipment investment. However, they involve high labor costs since a considerable crew is required to perform the operation and to clean and maintain the containers.

For the proposed plant, it is suggested that a slow-moving, troughed belt conveyor be used in performing the conditioning operation. 6/ The equipment should be so arranged that the moist granules move continuously from the discharge gate of the granulator onto the holding conveyor. At the discharge end of the conveyor the conditioned product should be fed directly to the fluffing unit used in the next operation. Provisions should be made to clean continuously the return section of the conveyor belt. Further details concerning the conveyor and cleaning mechanism are given in Table I.

231 — Fluffing

The object of the fluffing operation is to decompact the conditioned granules so that they will handle satisfactorily when fed to the preliminary drier and, also, to effect further separation of cell aggregates. The unit used in this operation is a double ribbon mixer.

In the existing industry fluffing is usually treated as a batch operation. However, for the proposed plant it is suggested that the mixer be of the continuous type. The conditioned granules should be

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5/ Although conditioning is here regarded as a separate step in the process, some conditioning action undoubtedly takes place during granulation, and may also occur during the time the potato mass is being fluffed in preparation for drying.

In a preceding section, granulation was also treated as a separate step. However, it is incorrect to assume that granulation ceases when the material is discharged from the granulator. Undoubtedly some separation of cells is effected after conditioning when the material is passed through the fluffing operation.

6/ It is believed that use of this type of conveyor will minimize labor costs to the extent that the additional investment involved will be defrayed in a one-year period.

continuously charged to the mixer, mixed for a period of 25 minutes, and continuously discharged to the drying operation. It is suggested that the tip speed of the outer ribbon of the fluffing unit be held at approximately 50 ft./min. Higher speeds may tend to cause excessive abrasion. Experts in the mixing field should be consulted concerning the design of the ribbons used in the mixer since the proper mixing and conveying action can only be obtained with ribbons of suitable pitch and dimensions. Further details concerning this unit are given in Table I.

240 — Drying

The driers used in existing potato granule plants are mainly of the pneumatic conveying type. It is reported, however, that one company is employing a large continuous tray drier in a recently constructed plant. Complete data pertaining to the design and operation of the various types of driers have not as yet been made public. In some instances, this kind of information is kept secret by plant owners. In other plants, some of the installations are so new that they have not been proved sufficiently to warrant public disclosure. Some equipment is still in the development stage and thus far has only been used successfully in small scale operation. Only for a horizontal duct drying system has any substantial information been made available. However, it has been found that potato cells are excessively fractured and abraded when dried in this system, with the result that the product tends to be sticky when prepared for table use. Consequently, this drying system cannot be recommended for use in future plants.

For the reasons given above, the descriptions herein of existing driers are necessarily incomplete. Moreover, definite recommendations as to a satisfactory drier design cannot be made at present.

1) Pneumatic conveying driers

In pneumatic conveying driers the material is rapidly dried by dispersing it in a hot air stream. Usually the drying time amounts to only a few seconds. The drier comprises a device for dispersing the moist granules in hot air, a duct or other enclosure through which air conveys the dispersed granules as they dry, and means for removing the dry product from the air stream.

Both the direct and the indirect methods of air heating are used in pneumatic conveying driers. In most of the existing potato granule plants the direct method of air heating is used, with natural or bottled gas as fuel. 7/

a) Horizontal duct drier

In this type of drier the material is dried as it is conveyed through a number of horizontal ducts. The installation at one granule plant consists of three duct elements. The three duct elements are so interconnected that they form a three-stage drying system. Each duct consists of a long horizontal section followed by a vertical section and a cyclone separator. In the separator, the granules are separated from the air.

7/ See Volume I, Chapter X, 240—Drying, "Sources of Heat for Dehydration Use".

It is known that impact and abrasion causes cell damage in the final drying stages (below 20% moisture content) when potato granules are dried in this system. High air velocities (from 3,000 to 10,000 ft./min. depending on the size and moisture content of the granules) are required to transport the heaviest particles through the horizontal ducts. As the granules are transported in the high velocity air stream they tend to shatter at duct bends and upon entering the cyclone separators. The operators of the aforementioned plant are installing air-lift driers of the type shown in Figure 14, for use in the last stage of the drying operation. In this stage of drying the granules are brittle and most susceptible to impact damage. The new driers tend to minimize cell injury because they are so designed that damage from impingement of granules against metal surfaces and from abrasion is greatly reduced. The plant operators have indicated that they would not install a horizontal duct drier when constructing a new plant.

b) Chivers & Sons air lift drier

F. J. Fison of Chivers and Sons, Ltd., Cambridge, England, has described this drier in a British patent. 8/ General features of the drier are shown in Figure 13. It is reported that driers of this type were used in producing over 6,000 tons of potato granules for the British Armed Forces during World War II. 9/ A number of these driers were shipped to the United States and are now in use at a potato granule plant in this country.

In the Chivers (or Fison) drier the granules are dried while being conveyed by a current of hot air through a vertical zigzag drying passage which is externally heated by steam. The larger and heavier particles proceed through the passage at a slower rate than the lighter ones and consequently there is a tendency for all particles to be of uniform moisture content when expelled from the drier. The zigzag passage is of narrow rectangular form (dimensions of 8-1/2" x 1-1/2" and 16" x 1-1/2" are given for the passage cross-section in the Fison patent) and is jacketed by a continuous casing. Because of its appearance, the jacketed passage is referred to as a tower. Steam is introduced into the jacket and so controlled as to maintain a slight pressure within the jacket. Normally, a number of these drying towers are bolted together and operated in parallel. Cyclone separators are provided to remove the dry product from the air leaving the drying towers.

According to reports, the granules are dried in two stages in these driers. One set of driers forms the first stage and reduces the moisture content to near 10%. The

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8/ Fison, F. J. Improvements in or Relating to a Method of and a Means for Drying Powdered or Other More or Less Finely Divided Material. British Patent 566,170 (June 11, 1943)

9/ Rendle, T. The Preservation of Potatoes for Human Consumption. CHEM. & IND. No. 45:354-9 (Nov. 1945)

partially dried product is then passed through a final-stage drier, where the moisture content is reduced to the specification level. It is said that air enters the first-stage driers at approximately 150° F. and leaves at 160° F. The air is held at slightly higher temperatures in the final stage of drying.

The product obtained through use of these driers is known to be of satisfactory quality. Although the granules pass along a tortuous path and through a cyclone separator in this equipment, impact and abrasion damage is much less severe than encountered in the horizontal duct drier. The reduction in damage is explained by the fact that the air velocity required to carry the granules through the vertical drying passage is much lower than required in a horizontal duct. Thus the particles travel at slower rates and impact and abrasion damage is correspondingly reduced.

Information regarding the capacity and physical dimensions of the Fison drier has not been made public. High construction and maintenance costs are said to be the principal factors that have discouraged use of this drier in recently constructed plants. One reason for high maintenance costs, it is reported, is that leaks tend to develop between the steam jacketed space and the drying passage.

c) Experimental air-lift drier

The experimental air-lift drier shown in Figure 14 was recently designed and tested at the Western Regional Research Laboratory (U. S. D. A.). Although the drier is still in the development stage, it is briefly described since several units of this type were recently installed for use in final-stage drying operations at one commercial plant. It is reported that satisfactory results are being obtained with the commercial plant units but the installation is so new that pertinent engineering data are not as yet available. Consequently, the present discussion is confined to the small-scale model used in pilot plant operations at the Western Regional Research Laboratory.

The experimental drier was designed specifically for study of the potato granule process and includes features that minimize impact and abrasion damage. In this drier a hot, dry, air stream conveys and dries the product in a vertical column (thus avoiding the very high air velocities that are required to convey material in horizontal duct driers). The column is free of bends and obstructions and consists of a vertical riser attached at the top to a diffuser. Air velocity is reduced as the conveying stream moves through the diffuser so that larger particles "dance" in the column until dry enough to be carried over the top. Smaller particles are dried sooner and pass out of the drier without appreciable delay. Above the diffuser, the product and air stream are directed downward by a deflector, and disengagement takes place in a receiver with air escaping upward, around the deflector, through an exhaust duct at the top. 10/

10/ Information concerning the design of the experimental drier may be obtained upon request addressed to the Western Regional Research Laboratory, U. S. D. A., Albany, Calif.

When used as a preliminary or first-stage drier (i.e., when drying granules from an initial moisture level near 37% down to 13% moisture) the air entering the drier is normally held at 350° F. and the air is discharged at 175° F. During final or second-stage drying the inlet air temperature is not allowed to exceed 325° F. and the granule feed rate is so controlled as to maintain the exhaust air at 175° F.

Results obtained with the experimental drier indicate that it is satisfactory for use in the dehydration of potato granules. Product damage during drying is negligible in the pilot plant model. However, it remains to be proved that the drier will perform satisfactorily in preliminary and final drying operations when scaled for commercial plant use. Additional information on the relationship between riser length and drying capacity and data concerning other design considerations must be secured before construction of large driers of this type can be undertaken on a rational basis. Work is being undertaken at the Western Regional Research Laboratory to provide this type of information.

d) Modified "P & L" air lift drier 11/

An air lift drier which is a modification of the "P & L" drier used in commercial fish meal drying operations was recently installed at one potato granule plant. Detailed information concerning the drier at this plant is not available. However, general features of the equipment are reported to be approximately as indicated in Figure 15 and described below.

At the bottom of the drier there is a narrow vertical duct where the moist granules are introduced and where upward air velocities are sufficient to carry the granules through a cone section and into the cylindrical body of the drier. As the granules dry they are carried upward through the body of the drier and to a cyclone separator where the dried product is removed from the air stream. Hot air is drawn through the drier by a suction fan mounted at the outlet of the cyclone separator. The air supply is obtained by mixing fresh air with hot combustion gases that are generated in a furnace, using butane gas as fuel. The heated air enters the base of the feed chamber.

Adjustable vanes installed inside of the drier body divert the air stream as it moves upward. A narrow open tube is concentrically placed in the drier body with one open end of the tube located near the bottom of the feed duct and the other near the top of the drier body. The design provides for a higher air velocity in the tube than in the feed duct. Any material that is too heavy to be entrained at the feed point drops and tends to be entrained by air entering the lower end of the tube. Upon leaving the upper end of the tube the heavy particles dry as they fall through the drying zone, and after one or more passes through the tube are light enough to be entrained in the main air stream.

11/ The "P & L" Air Lift Drier was developed by the P & L Welding and Machine Works, Inc., Anaheim, Calif.

2) Tray driers

It is possible to dry potato granules on trays in a cross-flow stream of heated air and obtain a satisfactory product. However, a disadvantage associated with this method is that the mash-to-seed ratio must be held at lower levels than instances where pneumatic conveying driers are used. The mash and "seed" must be used in such proportions that the mixture loaded on the trays has a moisture content between 30% and 35%. At moisture contents above 35% the particles tend to stick together as they dry on the trays, and a satisfactory yield of fine particles can not be obtained. In contrast, mixtures containing up to 40% moisture give satisfactory results when dried in a suitable pneumatic conveying drier. Thus, more "seed" must be recirculated in a plant that uses the tray drying method.

When granules are dried on trays it is desirable that the tray load be mixed occasionally during the course of drying. This procedure tends toward reduction in adhesion of particles during drying, higher drying rates, and greater product uniformity. The velocity of the air stream must normally be kept well below 200 ft./min., otherwise the particles will be swept off the trays and entrained in the air stream. For obvious reasons the drying time required with the tray method is vastly greater than in pneumatic conveying driers. To avoid scorching of the product, the air passing over the trays must be held at considerably lower temperatures than are used in pneumatic conveying driers.

At one commercial plant attempts were made to dry granules on trays in tunnel dehydrators. The trays were moved through the tunnels on trucks. This method, however, proved to be economically impractical and was abandoned. Because of the large recirculating load handled, labor and equipment costs were found to be excessively high.

A continuous tray drier was recently installed at this plant in order to reduce labor costs. In this drier the granules are intermixed periodically during the course of drying and all handling is performed by mechanical means.

The continuous tray drier used at the above-mentioned plant has been referred to as a modification of a vertical turbodrier. 12/ Details concerning the design of the drier used at this plant have not been made public, but the design is similar in some respects to that shown in Figure 16.

In vertical turbodriers of standard construction, a set of annular shelves are mounted in tier fashion inside of a framework which revolves slowly within a cylindrical housing. The shelves have either radial or annular slots, depending on the type of material handled. Heated air is moved radially across each tray by fans mounted on a vertical shaft which is concentrically placed in the open core formed by the annular shelves. The moist material is leveled at it is fed to the top tray. After the tray has revolved

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12/ Weisselberg, A. Vertical Turbodryer. INDUS. AND ENGIN. CHEM. 30 (9): 999-1000, 1938. Also see Chemical Engineers' Handbook 3rd Ed. p. 832, McGraw-Hill Book Co.

approximately one revolution the material comes into contact with a wiper blade, drops through the slot, and falls through a hopper onto the tray below, where the leveling and wiping operations are repeated.

The air may be heated by coils located either inside or outside of the cylindrical housing. In another design the hot air is generated externally, using the direct combustion method. Provisions can be made to admit the air to the drier at several levels and the temperature can be controlled throughout the downward travel of the material. Air may be recirculated to effect a saving in heat.

At the plant in question, difficulties involving entrainment of granules in the exhaust air have been encountered. It may be that entrainment occurs because of a defect in the design of the drier. On the other hand, it is possible that the air velocity is purposely held above prescribed levels so as to raise drying capacity, and the entrainment problem simply accepted as an unavoidable consequence. It is reported that a large dust separator has been installed at the plant to recover granules from the exhaust air stream.

243 — Air-lift drying

It is assumed that air-lift driers will be used in the proposed plant. However, as is evident from the preceding discussion, the information available on air-lift driers is too limited to warrant recommending a particular drier design at the present time.

243.1 — Preliminary drying

1) Drying

For the proposed plant the evaporation load in the preliminary drying step will be 3,200 lbs. of water per hour. Other important data pertaining to the preliminary drying operation are given in Figure 10 and Table I.

2) Granule cooling

The product discharged from the preliminary drier should be cooled to approximately room temperature before screening. Cooling of the hot product is necessary for the following reasons:

a) If the product is not cooled, moisture tends to condense on the screens in the subsequent screening operation with the result that the screens become fouled

b) The product will deteriorate rapidly if held at elevated temperatures for prolonged periods

c) Better results are obtained in the granulating step when the seed granules are cooled to near room temperature

In commercial plants various means are used to cool the dried product. In some instances a moderate amount of cooling is effected as the product moves on a long conveyor installed between the drier and the screening unit. An air lift drier, similar to that shown in Figure 14, is used at one plant. In the latter case cool air, instead of hot air, is supplied to the unit. In pilot plant operations an improvised air-slide cooler has been used successfully. In this unit the granules are cooled by air as they flow down an inclined strip of perforated metal. So as to obtain uniform distribution of air, the lower face of the perforated sheet is backed by a strip of canvas. 13/

3) Screening

The partially dried product is screened and separated into three sieve-fractions as indicated in Figure 10 and Table I.

It will be observed from the data given in Figure 10 that the stream of "seed" granules consists of all of the -24/ + 60 mesh screenings and a portion of the -60 mesh screenings. As is apparent from the discussion under Code 229, it is required that the weight of "seed" granules returned to the mash-seed mixing operation be sufficient to obtain a mash-seed mixture containing approximately 38% moisture. Obviously, the weight of "seed" required will vary with the moisture content of the product discharged from the preliminary drier.

On week-end shutdowns the "seed" granules needed for restoration of plant operation should be dried to a moisture content of approximately 7%. If "seed" containing approximately 13% moisture or higher is stored under unfavorable conditions, product quality will be impaired.

243.2 — Finish drying

1) Drying

It is assumed that an air-lift drier will be used in the final drying operation, where the moisture content of the potato granules is reduced from 12% down to the 7% maximum stipulated in current Military Specifications. The drier should have a water evaporating capacity of at least 65 pounds per hour. A drier with ample reserve evaporating capacity should be provided since there are some indications that the

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13/ The construction is similar to that of the Fuller-Huron Air-Slide conveyor (c.f. Bulletin FH-2, Fuller Huron Company, Catasaugua, Pa.)

Military Specifications may be amended to require that the moisture content of the product be reduced to a maximum of 6%.

2) Cooling

The product should be cooled approximately to room temperature by one of the methods previously outlined under Code 243.1 — 2.

250 — Screening and Inspecting

Military Specifications require that the finished product shall be of such particle size that 100 percent will pass through a U. S. Standard No. 40 sieve (sieve openings of 0.0165 inch). It is to be noted that the granules were passed through a U. S. Standard No. 60 sieve (sieve openings of 0.0098 inch) before finish drying. However, it is desirable to screen the final product since coarse granules or other noticeable foreign matter may be added inadvertently during the final drying operation. In most plants a U. S. Standard No. 50 sieve is used for screening the finished product.

At this stage in operations the procedure in some commercial plants is to store the dried product temporarily in multi-wall paper bags, drums, or hoppers and coded by lots. At the same time representative samples are sent to the plant laboratory, where moisture content, rehydration characteristics, texture, color, bulk density, etc., are determined. This procedure affords the opportunity of controlling the uniformity of the final pack by blending different production lots.

260 — Packaging and Packing

261 — Filling, packing, and sealing

Military Specifications stipulate that six pounds and two ounces of the product shall be packed in a No. 10 can.

The rate of handling of cans is low in the proposed plant and expensive or complicated equipment is not justified. In the proposed filling operation, cans are fed manually into the can-run and partially filled by means of a semi-automatic filler. The cans are then conveyed to a can jolter where the bulk volume of the product is reduced. During the jolting operation, the operator adds more product to the can until a 3/8-inch headspace remains, when approximately the required weight of product is in the can.

The filled cans are conveyed from the can jolter to a manual weighing station, where deviations from the required weight are corrected and a printed sheet of cooking directions added.

Storage tests indicate that oxygen greatly increases the rate of deterioration of the palatability, color, and vitamin content of potato granules. Military Specifications require that the oxygen content of the sealed container shall be below 2%. Before each can is sealed, the air in the interior must be replaced with nitrogen. The nitrogen is introduced into the cans as described in Chapter X of Volume I.

Cans should be purchased with lithographed or printed labels as required in Military Specifications. The date is stamped on each can at the time of packaging.

262 — Case forming, filling, sealing, and marking

Six cans of the product are packed in a case. Military specifications permit the use of either wood boxes or fiberboard cartons of definite types; the military bids and contracts will specify the exact types of packing to be supplied by the dehydrator. Present-day dehydrators use either mechanical or manual casing operations.

270 — Warehousing and Shipping

The cases are stacked on pallets and are transported by a lift truck to the shipping platforms or into the finished-product warehouse. All practical means should be taken to keep the temperature low in this warehouse in order to slow down the deterioration of the finished product. It is assumed that the pallets will not be shipped, and that the cases will be unloaded from the pallets in the shipping cars.

GENERAL FACILITIES

The requirements for other needed facilities have been discussed in Volume I, and the information will not be repeated here. The principal general facilities for the proposed plant will be similar to those listed in the "Cost of Facilities" in Part One of this Supplement.

325 — Waste disposal

The waste material from the preparation line should be disposed of as outlined under Code 325 in Part One of this Supplement.

BUILDINGS AND GROUNDS

Buildings and grounds for a potato granule plant should conform with the general requirements described in Volume I under "Plant Location" and "Selection of Plant Procedures and Facilities". Details relating to plant layout can not be given at present.

In general, this type of plant will require buildings and grounds somewhat similar to those discussed for the potato dice plant (Part One). Probable differences are in floor space and ceiling height requirements, which will be dependent upon the size and number of air-lift driers used.

CHAPTER IV

LIST OF POTATO GRANULE PRODUCTION FACILITIES

As is evident from the preceding discussion, the information now available is too limited to warrant estimation of production costs and capital requirements for the proposed plant. The following table lists the equipment considered likely to be used in new plants. Although the list is necessarily incomplete, it will assist in the actual planning of certain phases of a potato granule dehydration plant. _A prospective operator should avail himself of full information on the latest technological advancements in this field of dehydration and become thoroughly familiar with all of the problems involved in producing a satisfactory product before proceeding with the planning of a commercial plant._

TABLE I — PLANT EQUIPMENT FOR A 50-TON PER DAY POTATO GRANULE DEHYDRATION PLANT
LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
		200 -- MANUFACTURING OPERATIONS FACILITIES				
210 -- Raw Material Handling						
211 -- Weighing (at plant)						
a.	Truck scales: To weigh incoming loads of raw commodity (not required by plants which have access to public scales)	Type "S" Motor Truck Scale Fairbanks-Morse & Co. Code 6512	10' x 60' platform scale; 50 ton capacity; weighing indicator with type registering beam for recording weights; steel frame timber deck; reinforced concrete foundation and pit with sump pump and accessories	1		
213 -- Feeding to line						
a.	Conveyor: To move potatoes from distant points in the plant storage house to the elevator conveyor	FMC	Flat-belt conveyor, equipped with stationary aprons; oil-less bronze bearings for idler rolls; steel construction; complete with motor drive	1		
b.	Elevator: To move potatoes from the discharge end of plant storage house conveyor and elevate to processing line	FMC Fig. 5071	Standard cannery elevator-conveyor; 24" wide; steel construction with steel draper and flights supported on pintle chain; conveyor sloped 60° or less; constant speed motor drive	1		
c.	Conveyor: To move potatoes past inspection stations for removal of "rots," stones, and other foreign materials	FMC Fig. 580	Flat belt conveyor, equipped with stationary aprons; 36" wide; steel idler rolls; hopper on discharge; steel construction; complete with motor drive	1		
220-230 -- Preparing						
221 -- Washing						
a.	Elevator-prewasher: To elevate potatoes from inspection conveyor to washer; and to partially wash off or soften dirt	FMC Fig. 5761	Boot type elevator-conveyor; 24" wide; length to suit location; galvanized wire-mesh belt and metal flights; two rows of overhead spray nozzles; steel construction; complete with motor drive	1		
b.	Rotary washer: To remove dirt and foreign matter from potatoes	FMC Fig. 431	Rod-type rotary washer; 25" dia. by 6' long reel; center spray; 15 r.p.m.; 1-1/2 h.p. motor drive; steel construction	1		
222 -- Preheating						
a.	Elevator: To elevate potatoes from the washer to the preheater	FMC Fig. 5071	24" wide x 12' discharge height standard elevator; all steel construction with slats and flight draper carried by side chains; complete with 1-1/2 h.p. motor drive	1		
b.	Preheater: To preheat potatoes before peeling	Custom built (see Fig.9)	Rotary heater; 6,000 lbs. per hour capacity; variable speed drive for 4 to 7 minute retention; heating by direct steam mixing; steel construction; similar to lye peeler, SRRL design, modified for preheating; complete with temperature controls	1		
223 -- Peeling						
223.2	- Lye peeling					
a.	Lye peeler: To loosen or remove skins from the potatoes	Custom built (see Fig.9)	Rotary lye peeler; 6,000 lbs. per hr. capacity; steam heating coil; variable speed drive for 2 to 4 minutes retention; steel construction; SRRL design complete with temperature controls	1		
b.	Caustic soda cut-back tank: To dilute the concentrated lye solution to the proper strength for feeding to the lye peeler	Custom built	4' dia. x 6' high welded steel tank; 500 gal. capacity	1		
c.	Lye storage tank: To store concentrated caustic soda solution	Standard construction	15,000 gallons capacity; for underground storage, with pump, piping and accessories	1		

LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
223.9	-- Washing					
a.	Rotary washer: To wash skins and caustic solution off potatoes	FMC Fig. 431	Rod-type rotary washer; 25" dia. by 6' long reel; center spray; 15 r.p.m.; 1-1/2 h.p. motor drive; steel construction	1		
224	-- Trimming & inspecting					
a.	Conveyor: To move the sliced potatoes past trimming and inspection stations and to convey potatoes from slicer to cooker	FMC Fig. 435-A	Woven-wire belt conveyor; 30" wide by 16' long; steel construction; complete with motor drive	1		
225	-- Washing					
a.	Washer: To spray rinse the sliced potatoes after trimming	FMC	Woven-wire belt conveyor; equipped with overhead water sprays; size and type depends on plant layout	1		
226	-- Cutting (slicing)					
a.	Slicing machine: To form 5/8" slices or slabs by cutting the potato lengthwise	Urschel Model B	Standard dicer; modified to cut 5/8" slices	2		
227	-- Cooking					
a.	Cooker: To cook sliced potatoes	FMC Fig. 9332 modified to meet specification	Continuous atmospheric steam cooker; 4,600 lbs. per hr. capacity; 30' approximate covered length; 6' wide, stainless steel, woven-wire belt conveyor; clearance for 6 to 8 inches maximum loading depth; variable speed drive for 25 to 45 minute retention in cooker; spreader bar at inlet to uniformly load 5/8" slices up to 8" deep; fixed side guides at entrance, aprons on each side along interior; complete with temperature controls	1		
b.	Cooling conveyor: To cool the cooked potato slices and convey same to mashing rolls	Link-Belt Co.; Chain Belt Co.; FMC; etc.	Belt conveyor; stainless steel woven-wire belt 6' wide; 4,600 lbs. per hr. capacity; slices to be spread 3" thick and held on belt for approximately one minute; steel construction; constant speed motor drive; with hood to convey vapors to exhaust fan	1		
228	-- Mashing					
a.	Mashing rolls:)To mash potato slices	Custom built (see Fig. 11) -- F.J. Stokes Machine Co.; Patterson Foundry and Machine Co.; Buflovak Equipment Div., Blaw-Knox Co.	Double drum potato masher, with 18" dia. by 4' long drums; 4,600 lbs. per hr. capacity; adjustable clearance between rolls, 0.050 in. nominal clearance; drum surfaces to be hard chrome plated and highly polished; drum speed to be approximately 70 r.p.m.; equipped with plastic doctor blades and shear bolts; construction is similar to atmospheric double drum drier	1		
229	-- Mixing, granulating, and sulfiting					
a.	Weighing machine: To weigh and deliver predetermined amounts of mashed potato to the ribbon mixer	Toledo Scale Co.; Exact Weight Scale Co.; B.F. Gump Co.; etc.	Automatic weighing device; 4,600 lbs. per hr. capacity; sanitary construction, designed to weigh predetermined amounts of mashed potato (bulk density approximately 45 lbs. per cu. ft.) and to discharge intermittantly at 30-second or shorter intervals; synchronized with seed granule weigher so as to maintain a predetermined mash-to-seed ratio	1		

LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
b.	Weighing machine: To weigh and deliver a predetermined amount of seed granules to the ribbon mixer	Toledo Scale Co.; Exact Weight Scale Co.; B.F.Gump Co.; etc.	Automatic weighing device; 7,100 lbs. per hr. capacity; sanitary construction; designed to weigh predetermined amounts of seed granules (bulk density approximately 40 lbs. per cu. ft.), and to discharge intermittantly at 30-second or shorter intervals; operation of weigher to be synchronized with mashed potato weigher	1		
c.	Ribbon mixer: To mix the mashed potatoes and seed granules	#6, Type G modified as required to meet specifications; Patterson Foundry & Machine Co.	Continuous double ribbon mixer; approximately 36" wide by 42" deep by 6' long; conveying type with inlet and discharge at opposite ends; adjustable discharge gate; stainless steel interior and ribbon; removable access covers to facilitate thorough cleaning; constant speed motor drive; 10 r.p.m. maximum shaft speed; equipped with shaft seals and outboard bearings; 12,000 lbs. per hr. capacity with mixer 2/3 full (mixture apparent density 45 lbs. per cu.ft.); retention time in mixer to be approximately 5 minutes	1		
d.	Granulater: To granulate the mash-seed mixture	Custom built -- B.F. Gump Co.; J.H. Day Co.; Robinson Mfg. Co.	Continuous horizontal mixer with adjustable paddle-type steel agitator; approximately 36" wide by 42" deep by 20' long; conveying type with inlet and discharge at opposite ends; equipped with adjustable discharge gate; removable covers to facilitate thorough cleaning; constant speed motor drive to obtain 5 r.p.m. shaft speed; shaft seals, and outboard bearings; 12,000 lbs. per hr. capacity with mixer 2/3 full (apparent mixture density 35 lbs. per cu.ft.); retention time in mixer to be approximately 20 minutes; equipped with 150 c.f.m. exhaust fan for moving air, as indicated in Figure 12	1		
e.	Sulfiting equipment	- - - - -	See text under Code 229	-		
230 -- Granule conditioning						
a.	Conveyor: To hold moist granulated potato for conditioning	Link-Belt Co. series 400; Chain Belt Co.; Jeffrey Mfg. Co.	Troughed belt conveyor, approximately 70 ft. long with flexible neoprene belt 72" wide; 1' per min. nominal belt speed; constant speed motor drive; steel frame support; 12,000 lbs. per hr. capacity; retention time on belt to be 70 minutes; provide hood to exclude dust	1		
b.	Belt washer: To clean return section of conditioning conveyor belt	Custom built -- Link-Belt Co.; Chain Belt Co.; Jeffrey Mfg. Co.	Rotary brushes and steam nozzles arranged to clean continuously the belt surfaces; cleaning unit to be located in enclosure near discharge end of conveyor; provide duct and flume or other means for removing waste steam and dislodged granules	1		
231 -- Fluffing						
a.	Fluffer: To fluff moist granules preparatory to feeding to the drier	Custom built -- B.F. Gump Co.; J.H. Day Co.; Robinson Mfg. Co.	Continuous double ribbon mixer, approximately 36" wide by 42" deep by 20' long; inlet and discharge at opposite ends; adjustable discharge gate; removable access covers to facilitate thorough cleaning; steel ribbon and black iron body; constant speed motor drive to turn shaft at 5 r.p.m.; equipped with shaft seals and outboard bearings; 12,000 lbs. per hr. capacity with mixer 3/4 full (mixture apparent density 35 lbs. per cu.ft.); retention time in fluffer to be approximately 25 minutes	1		

LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

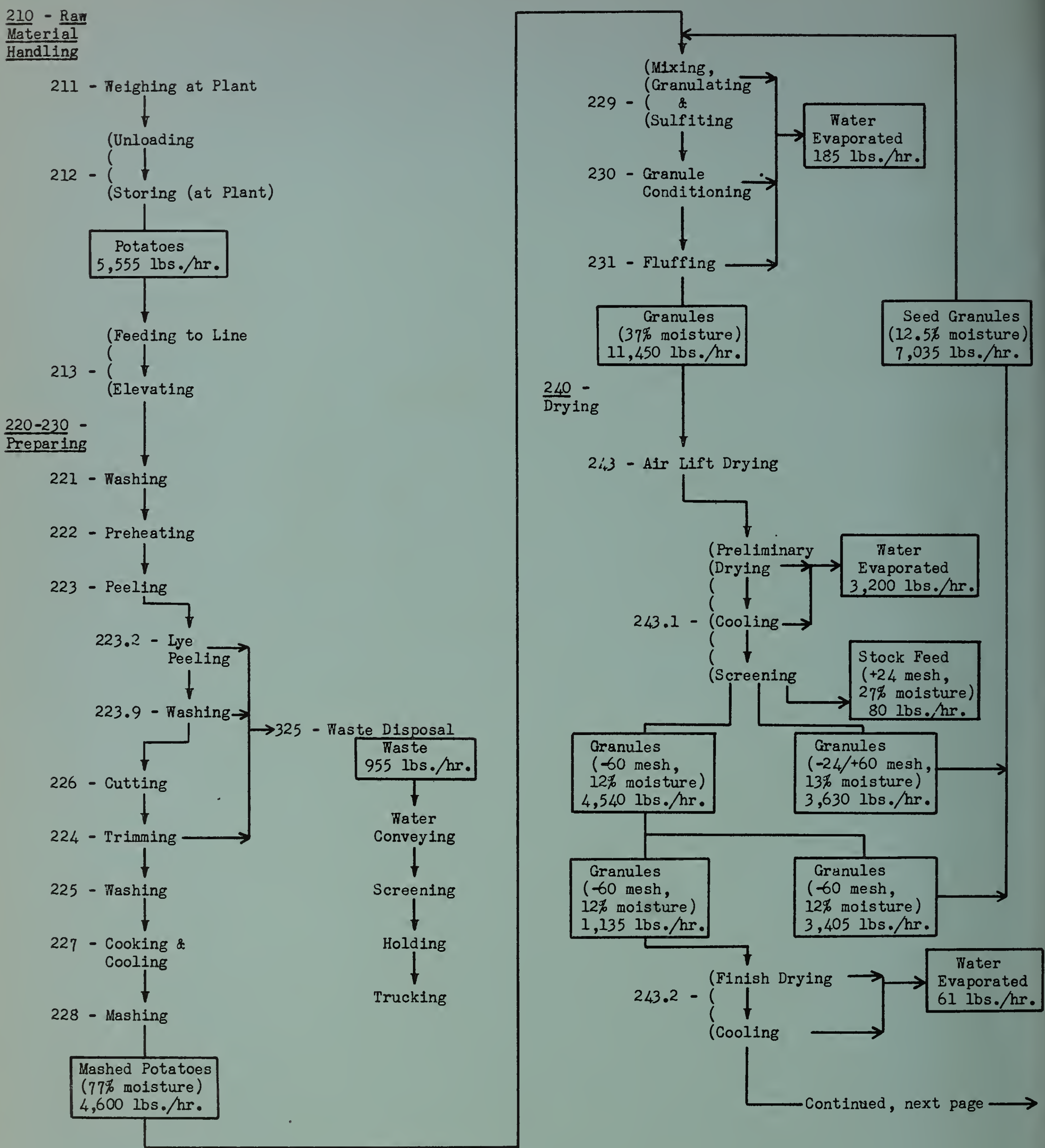
Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
240 -- Drying						
243 -- Air lift drying						
243.1 -- Preliminary drying						
a.	Preliminary drier: To reduce moisture content of the granules from approximately 37% to 13%	See text under Codes 240 & 243.1	Air lift drier, 3,200 lbs. per hour water evaporating capacity	1		
b.	Granule cooler: To cool the partially dried product to a temperature near 80°F		See text under Code 243.1			
c.	Screen: To separate the partially dried potato granules into three sieve fractions	Southwestern Engineering Co.; Link-Belt Co.; Productive Equipment Corp.	Double deck vibrating screen, with U.S. Standard Sieve No. 24 on upper deck and U.S. Standard Sieve No. 60 on lower deck; separate discharge spouts for +24 mesh, -24/+60 mesh, and -60 mesh screenings; readily disassembled for cleaning; 8,250 lbs. per hr. capacity; complete with motor drive	1		
243.2 -- Finish drying						
a.	Finishing drier: To reduce the moisture content of the partially-dried granules from 12% down to 7%	See text under Codes 240 & 243.2	Air lift drier; 70 lbs. per hr. water evaporating capacity	1		
b.	Granule cooler: To cool the dried product to a temperature near 80°F.		See text under Code 243.1			
250 -- Screening and Inspecting						
252 -- Screening						
a.	Screen: To separate foreign and oversized materials from the final product	Southwestern Engineering Co.; Link-Belt Co.; Syntron Co.	Single deck vibrating screen; equipped with U.S. Standard Sieve No. 50 and separate discharge spouts for +50 and -50 mesh screenings; readily disassembled for cleaning; 1,100 lbs. per hr. capacity, complete with motor drive	1		
260 -- Packaging and Packing						
261 -- Filling, packing, and sealing						
a.	Elevator-conveyor: To transport the finished product to the filler hopper	- - - - -	Conveyor, 1,100 lbs. per hr. capacity; type and length dependent on plant layout	1		
b.	Can filler: To deliver the required weight of potato granules into No. 10 (603 x 700) cans	Berlin Chapman Co.	Filler, semi-automatic type; adjustable as to volume of fill; 180 cans per hr. capacity	1		
c.	Can jolter attachment: To jolt filled cans so as to settle potato granules in the container	Custom built	Mechanical device for delivering sharp, repeated blows on bottom of each can at a rate of approximately 4 blows per second; jolter attachment may be either a part of the can conveyor or a separate unit that is installed between the filler and check-weighing scales	1		
d.	Can conveyor: To convey filled cans past the check weighing scales and to deliver them to the closing machine	FMC; Link-Belt Co.; American Can Co.	Flexible belt conveyor, 7 in. width, length to suit location; including can stops, discharge table, feed shelf, and motor drive	1		
e.	Check weighing scales: To check-weigh filled cans	FMC Fig. 2150 Model C-27-05	Detectogram general purpose scale; 10 lbs. capacity	2		
f.	Can closing machine: To seal covers on cans	American Can Co. No. 1	Semi-automatic machine, operated by depressing foot treadle; complete with 1-1/2 h.p. motor drive	1		

LIST OF FACILITIES

(NOTE: THE MANUFACTURERS LISTED ARE NOT RECOMMENDED OVER OTHER MANUFACTURERS OF SIMILAR EQUIPMENT)

Code Number & Operating Steps	Equipment Needed & Function	Acceptable Model (& Ship. Wt.)	Description of Equipment	No.	Cost Per Unit	Approximate Total Cost
g.	Vacuumizing & gassing chamber: To replace air (in cans of product) with inert gas	American Can Co. No. 3	Consists of vacuum chamber holding 10 #10 cans; includes trays, gas expansion tank, filter, vacuum regulator, 3-way valve, and stand	2		
h.	Vacuum pump: To draw vacuum of 29.5" in vacuumizing and gassing units	Beach-Russ Co. Model No. 50-D	High vacuum pump; rotary-piston, dry-vacuum type; 58 c.f.m. capacity, water cooled	2		
i.	Gas piping assembly: To reduce pressure of gas from gas cylinders, provide gas storage at intermediate pressure, and convey gas to vacuumizing and gassing units	Custom built	High pressure manifold for 6 gas cylinders; 2 pressure reducing valves; 1 intermediate pressure storage tank; including required pipe lines	1		
262 -- Case forming, filling, sealing and marking						
a.	Case branding machine: To mark cases in accordance with specifications	FMC Fig. 8072	Automatic machine equipped to handle box shook and flat fiber cases; complete witg 1 h.p. motor drive	1		
b.	Case sealing machine: To seal top and bottom flaps on fiber cases	Elliott Mfg. Co. Model A	Fully automatic sealer with 16' compression section; complete with 3/4 h.p. motor on gluing section, and 3/4 h.p. motor on compression section	1		
270 -- Warehousing and Shipping						
271 -- Palletizing						
a.	Pallets: For use in warehousing filled cases and handling empty cans	Custom built	Wood construction, 48" by 60"; double faced; sufficient number of pallets for plant operation and warehousing for up to 30-days' production	-		
b.	Lift truck: For handling and transporting palletized loads in warehouse	Yale Model KG 51-T-40-U	Capacity 2 tons, gasoline engine	1		

Figure 10 -- FLOW SHEET FOR POTATO GRANULES DEHYDRATION
(Capacity - 50 Raw Tons per Day)



Continued from preceding page

250 - Screening & Inspecting

251 - Elevating

252 - Screening

(Inspecting
255 - (
(Conveying

Potatoes, Dehydrated
Type IV, Class I
(Granules, 7% moisture)
1,074 lbs./hr.

260 - Packaging & Packing

261 - Filling, Packing & Sealing

Elevating

Filling & Weighing

Can Closing

Gas Filling

Soldering (of lid hole)

#10 Cans
175.3/hr.

262 - Case Forming, Filling, Sealing & Marking

Casing

Sealing

Cases
29.2/hr.

270 - Warehousing & Shipping

271 - Palletizing

272 - Warehousing

273 - Shipping

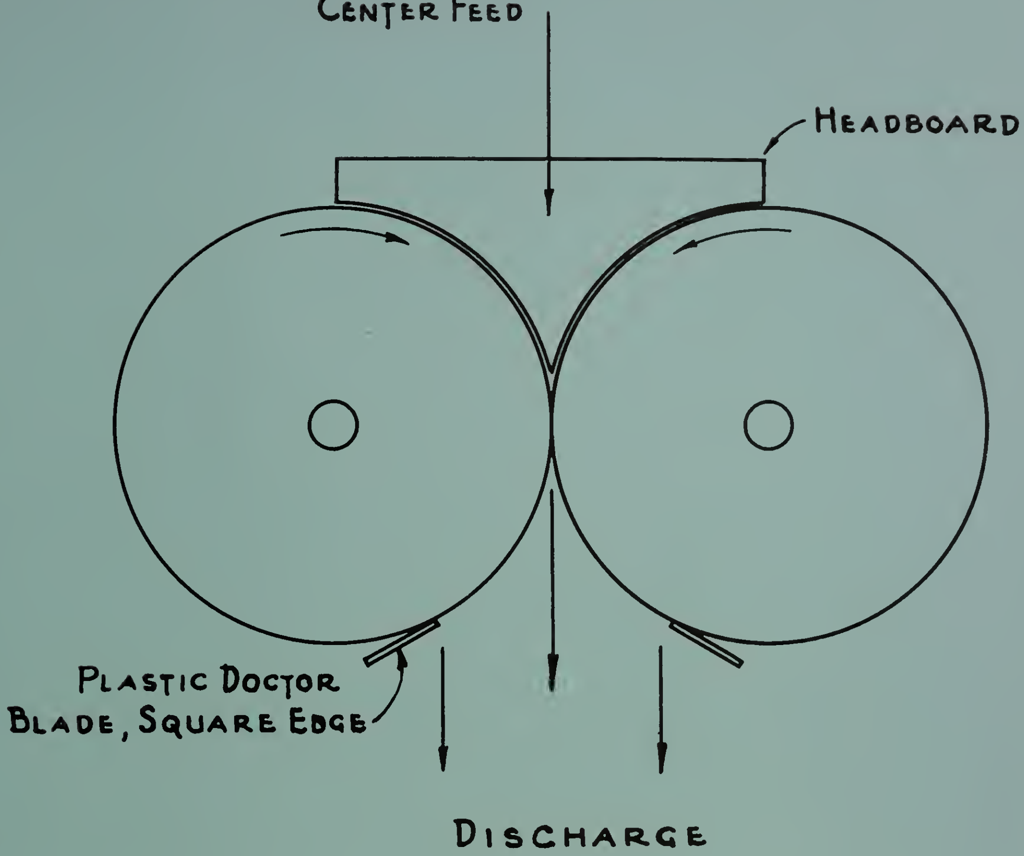


FIGURE No. 11

DOUBLE DRUM POTATO MASHER

(SIMILAR IN CONSTRUCTION TO A DOUBLE DRUM DRIER WITHOUT HEATING ACCESSORIES)

(CODE 228)

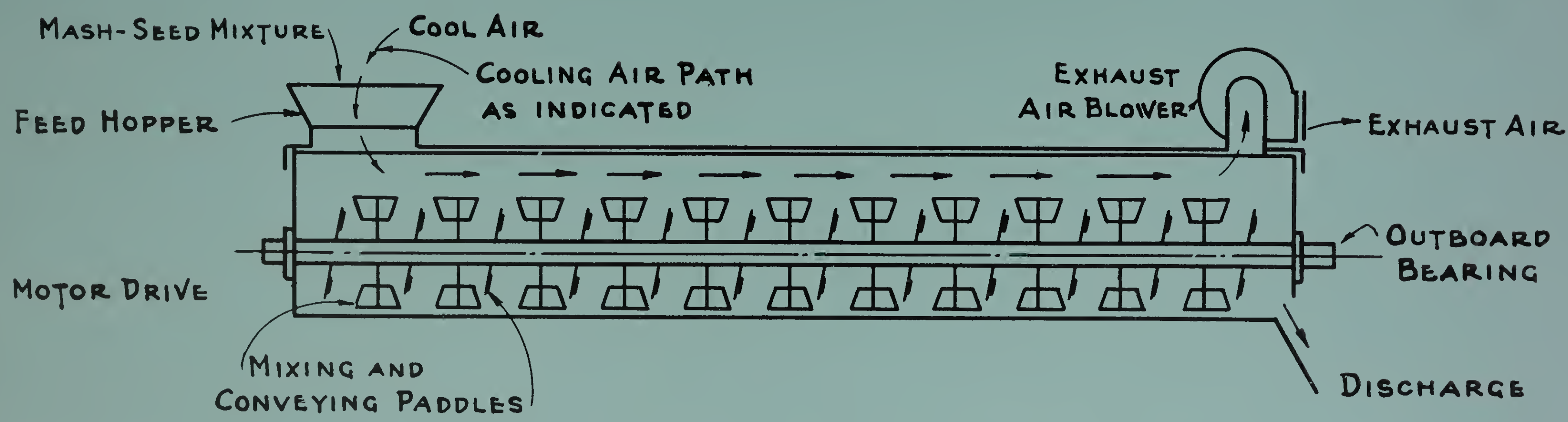


FIGURE No. 12

GRANULATOR

(CODE 229)

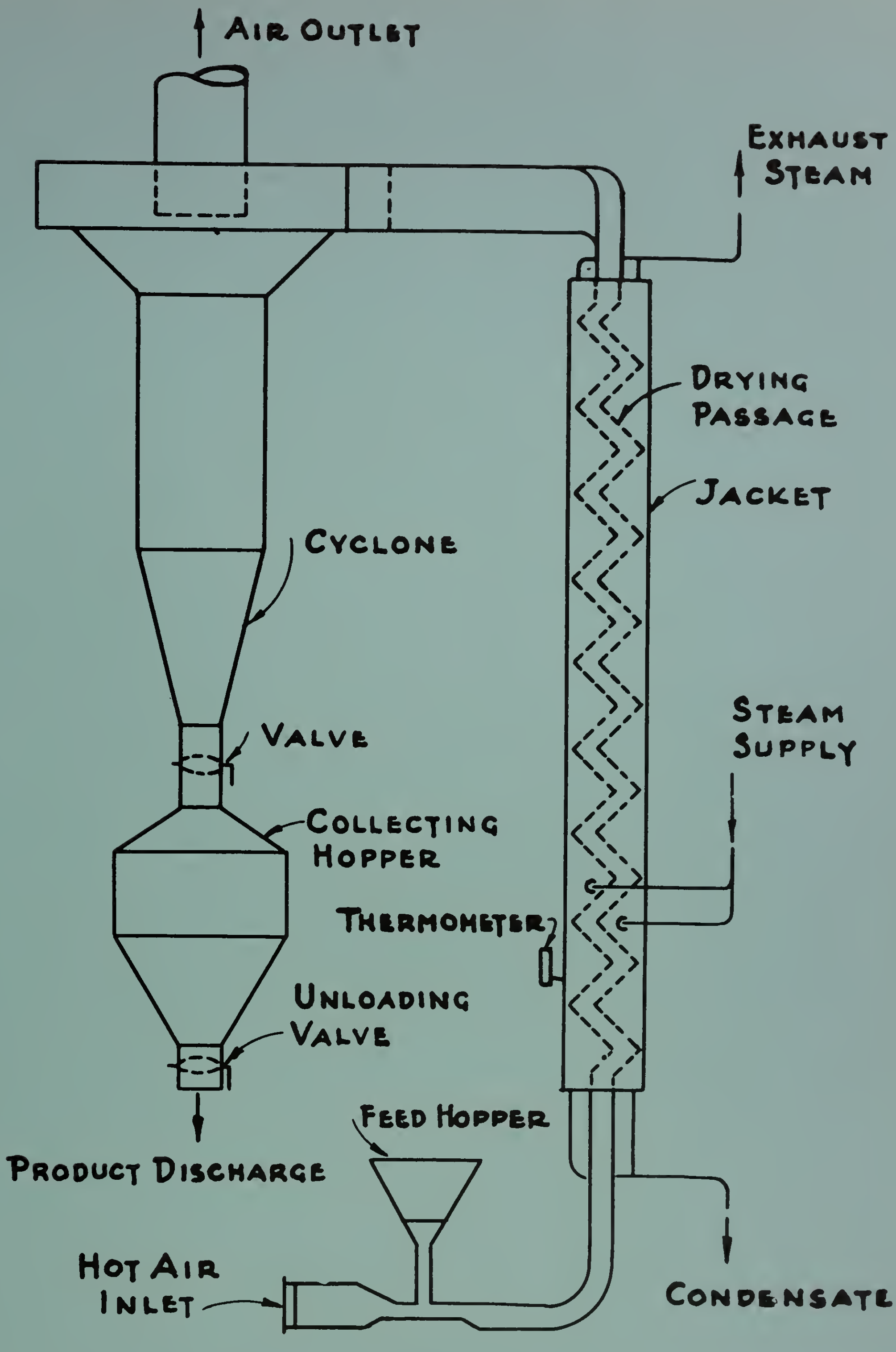


FIGURE No. 13

GRANULE DRIER, CHIVERS & SONS LTD.

(COPIED FROM BRITISH PAT. No. 566,170 - FIG. No. 1)

(CODE 240)

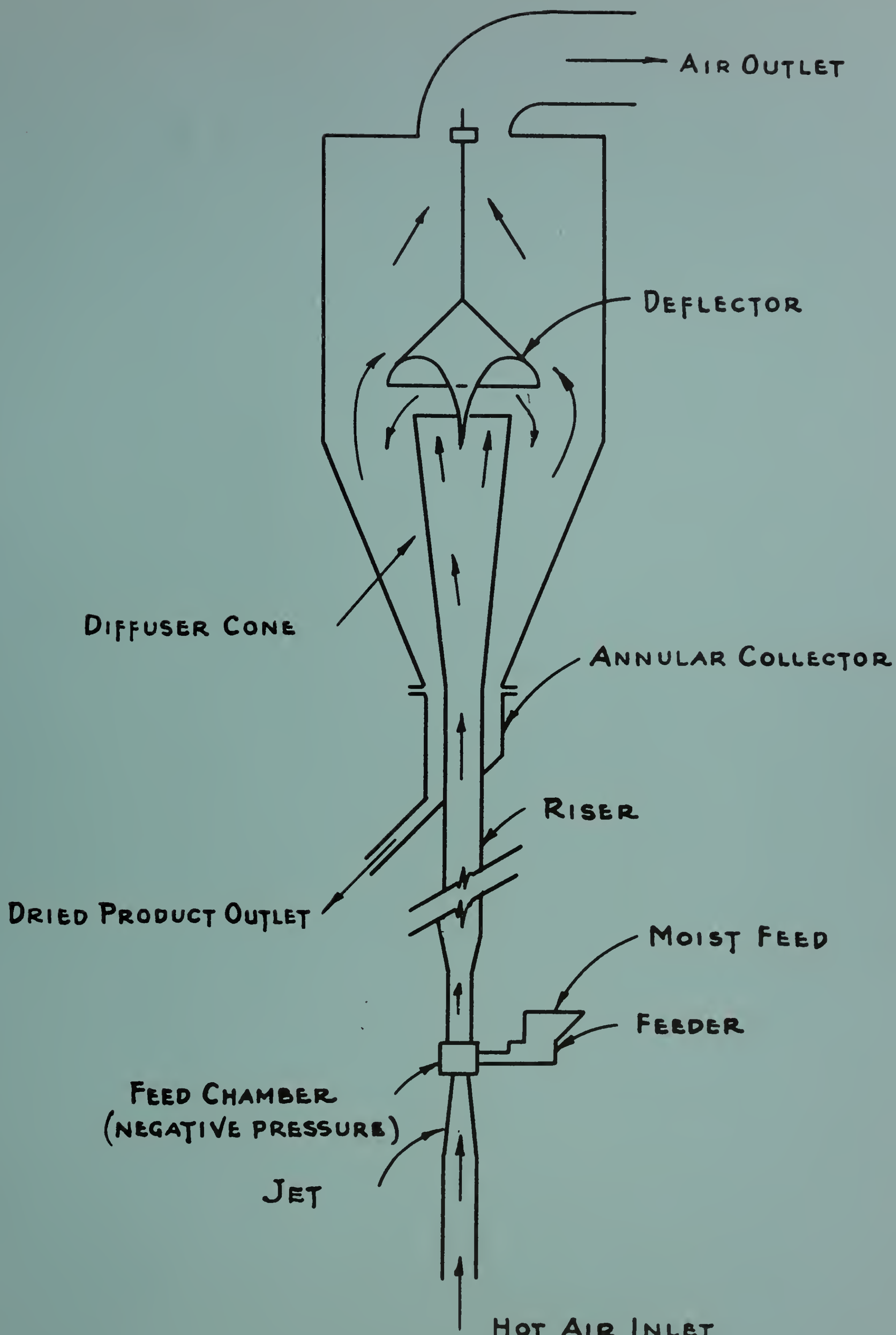


FIGURE No. 14

EXPERIMENTAL AIR LIFT DRIER

(CODE 240)

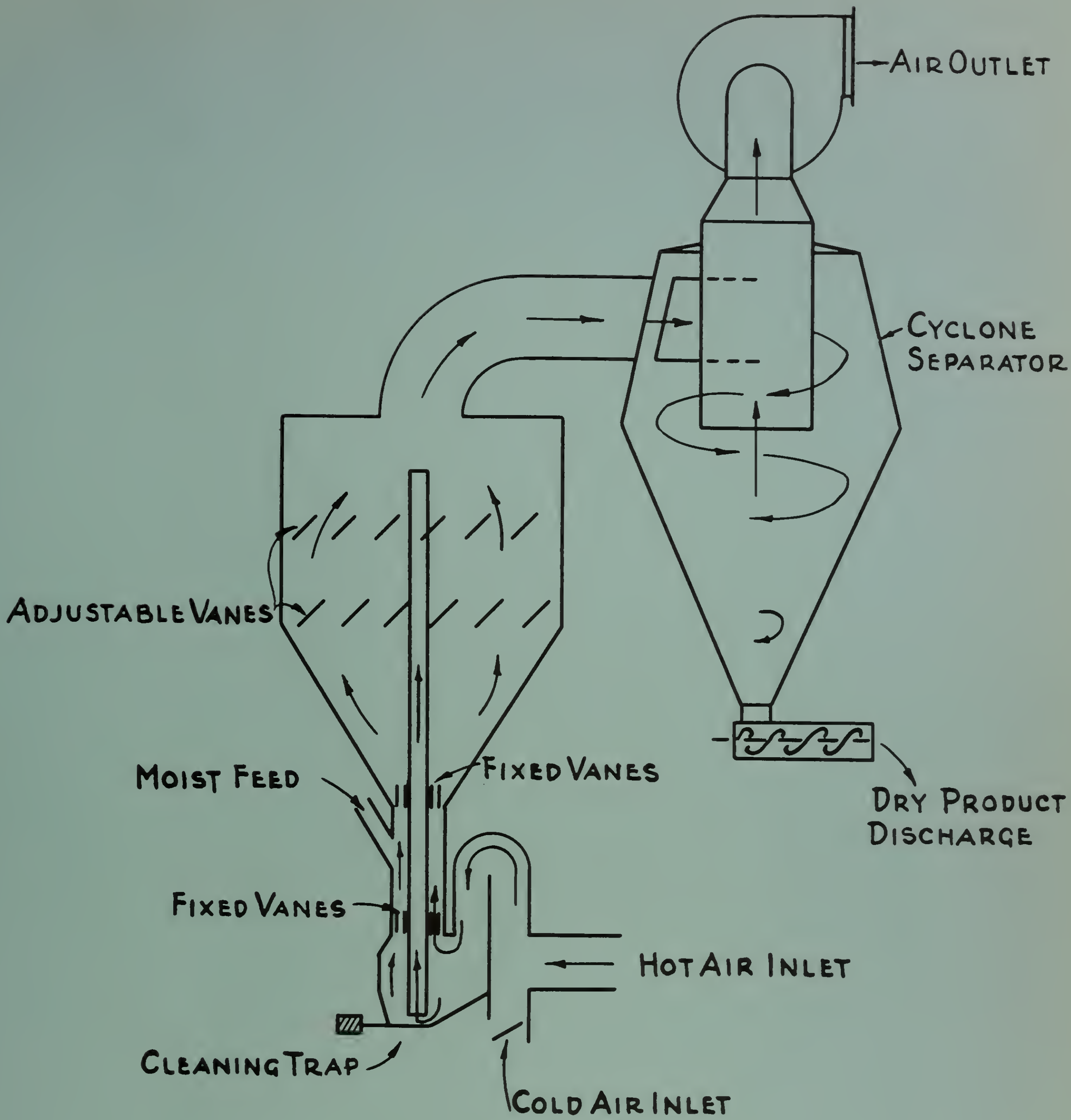


FIGURE No. 15

MODIFIED P.&L. AIR LIFT DRIER

(CODE 240)

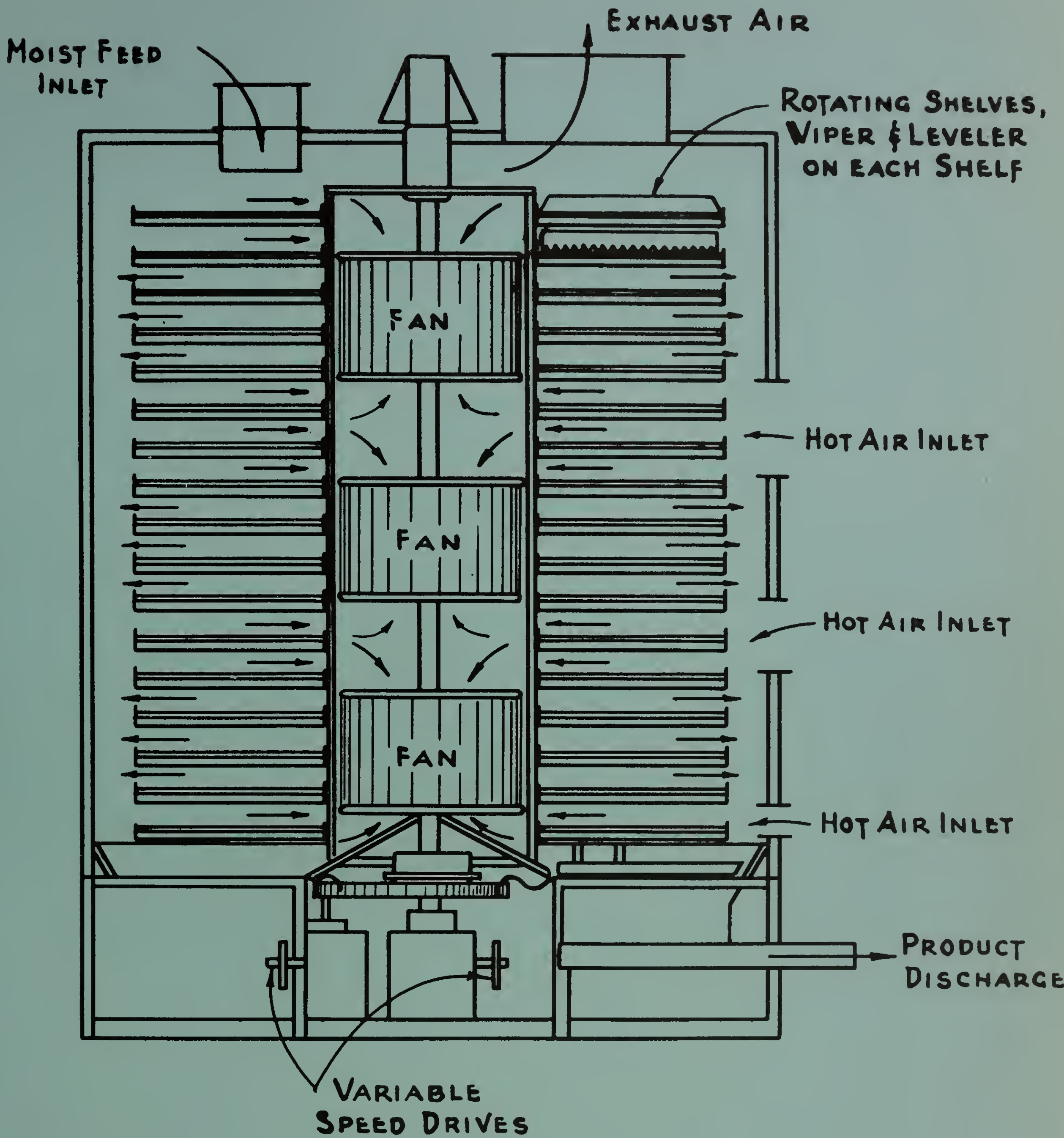


FIGURE No. 16

MODIFIED TURBODRIER

(CODE 240)

GPO 86—094217